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Engineering Library

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CXVI.—No. 3016.] *LONDON: FRIDAY, OCTOBER 19, 1923.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 3½d.

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AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

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See half-page Advert. last week and next week. 1382

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See Advertisement last week, page 86.

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See page 17. 1134

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See Advertisement, page 73, Oct. 12.

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See their Illus. Advertisement, page 89, last week.
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See our Illustrated Advertisement, Oct. 12.

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&c., &c. 1536

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Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW - BIRMINGHAM - LONDON.
See Advertisement, page 100. 1111

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PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES.
AIR COMPRESSORS.
REFRIGERATING PLANT. 1475
See Advertisement, page 53, Oct. 12.

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Including Machine Moulded GEAR WHEELS up to 10 feet dia.
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MECHANICAL ENGINEERS,
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YARROW BOILERS. 1553

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See Full Page Advt., page 60, Oct. 12.

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Walter Somers, Limited,
HALESOWEN. 7116

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For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
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See advert., page 48, Oct. 12. 8195

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Forgings, Castings, Bars, Sheets, Wire, Tubes.
THE DELTA METAL CO., LTD., 1334
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AUCTIONEERS, VALUERS AND SURVEYORS
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ENGINEERING AND ALLIED TRADES
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Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 1676
See half-page Advertisement, page 36, Sept. 28.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
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Civil Service Commission.

FORTHCOMING EXAMINATION: PROBATIONARY INSPECTORS in the Engineer-in-Chief's Department of the General Post Office (17-22, with extension for service in H.M. Forces during the War), 15th November.
The date specified is the latest on which applications can be received. They must be made on forms to be obtained, with particulars, from THE SECRETARY, Civil Service Commission, Burlington Gardens, London, W.1. B 919

PUBLIC LECTURES ON

"Physics in Industry."

THE INSTITUTE OF PHYSICS.

The Fifth Lecture of this series on "THE PHYSICIST IN THE TEXTILE INDUSTRIES" will be delivered by Dr. A. E. OXLEY, Physicist to the British Cotton Industries Research Association, on MONDAY, OCTOBER 22nd, 1923, at 5.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C.2. The Hon. Sir CHARLES PARSONS, K.C.B., F.R.S., Pres. Inst. P., will preside.

F. S. SPIERS,
Secretary,
10, Essex Street,
London, W.C.2. B 896

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and SALES MANAGEMENT.—Write for brochure describing our special Course of training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 1723

Power and Speed of Vessels.

—Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 1463, Offices of ENGINEERING.

TENDERS.

The Director-General,

India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E.1.
REQUIRES:—
1. RAILS and FISHPLATES. Part required middle of December, 1923.
2. POSTS and WEDGES for Fencing, wrought iron.
3. WIRE, 7 strand, fencing, galvanized.
4. MILD STEEL for making rivets.

Tenders due on the 30th October, 1923, for No. 1, and on the 6th November, 1923, for Nos. 2 to 4.
Tender Forms obtainable from above. B 905

CITY OF LIVERPOOL.

LANCASHIRE BOILERS.

The Corporation invite

Tenders for the Supply and

DELIVERY of THREE LANCASHIRE BOILERS and FITTINGS at the Public Baths.
Specification and other particulars may be obtained on application to the Engineer and Chief Superintendent, Bath Department, 75, Dale Street, on payment of One Guinea, which will be returned on receipt of a *bona-fide* Tender.
Tenders must be enclosed and sealed up in the official envelope provided, and delivered by letter post at the Town Clerk's Office, not later than Noon, on Tuesday the 13th November next.
The Corporation do not bind themselves to accept the lowest or any Tender.
WALTER MOON, Town Clerk.
Liverpool, 12th October, 1923. B 904

STATE ELECTRICITY COMMISSION OF VICTORIA.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.
Copies of Tender Form and Specification will be available upon application to:—
AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C.2.
Specification No. 24/1—
ALUMINIUM STEEL CORED CABLE AND ACCESSORIES.
Charge:—10s. for the first two copies of Tender Form, Conditions of Contract and Specification complete. This charge will be returned on receipt of a *bona fide* Tender. A third copy and any further copies will be supplied for the sum of 5s. each. This charge is not returnable.
Preliminary Deposit:—A Preliminary Deposit of £100 is to be lodged with the Tender.
The Specification may be inspected at the above-mentioned office.
The Commission does not bind itself to accept the lowest or any Tender.
Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne, not later than 5 p.m., 3rd January, 1924.
R. LIDDELOW,
Secretary,
State Electricity Commission of Victoria,
Melbourne, Victoria,
Australia. B 848

LONDON AND NORTH EASTERN RAILWAY.

The Directors are prepared to receive

Tenders for the Supply of

STEELWORK for the RENEWAL of HONEYPOT LANE BRIDGE, at Darlington. The Contract comprises about 88 tons of Steel Troughs and Decking rivetter up, painted, etc., but does not include erection.
Drawings and Specifications may be seen, and detailed quantities and Form of Tender obtained, on personal application at the office of the Chief Engineer, North-Eastern Area, York. Sealed Tenders, marked "Tender for Honeypot Lane Bridge, Darlington," must be received by the Joint Secretaries, London & North Eastern Railway, Marylebone Station, London, N.W.1, by Nine a.m., Thursday, October 25th.
The Directors do not bind themselves to accept the lowest or any Tender.
JAMES McLAREN, } Joint Secretaries.
G. F. THURSTON, }
Marylebone Station,
London, N.W.1,
11th October, 1923. B 892

LONDON AND NORTH EASTERN RAILWAY.

The Directors are prepared to receive

Tenders for the Supply and

ERECTION of STEELWORK for the RENEWAL of SHEEPFOLD ROAD BRIDGE and SHEEPFOLD SOUTH BRIDGE, at Monkwearmouth. The Contract comprises the whole of the Steelwork, about 77 tons in Troughs, Decking, etc. Timber Way Beams, Concrete in troughs and foundations, Rock Asphalt, etc., and also includes the Removal of Part of the Existing Structure, but not the relaying of the Permanent Way on completion.
Drawings and Specifications may be seen, and detailed quantities and Form of Tender obtained, on personal application at the Office of the Chief Engineer, North-Eastern Area, York. Sealed Tenders, marked "Tender for Sheepfolds Bridges, Monkwearmouth," must be received by the Joint Secretaries, London & North Eastern Railway, Marylebone Station, London, N.W.1, by Nine a.m. on Thursday, October 25th.
The Directors do not bind themselves to accept the lowest or any Tender.
JAMES McLAREN, } Joint Secretaries.
G. F. THURSTON, }
Marylebone Station,
London, N.W.1,
11th October, 1923. B 893

LONDON AND NORTH EASTERN RAILWAY.

The Directors are prepared to receive

Tenders for the Strengthening

of SKIP BRIDGE, over the River Nidd, between the stations of Marston Moor and Hammerton, on the York and Harrogate branch. The contract comprises the Supply and Erection of the whole of the Steelwork, about 31 tons, cast Iron Work, &c., and also the REMOVAL of CERTAIN PARTS of the EXISTING STRUCTURE.
Drawings and Specification may be seen, and detailed quantities and Form of Tender obtained, on personal application to the Office of the Chief Engineer, North-Eastern Area, York. Sealed Tenders, marked "Tender for Skip Bridge, York, and Harrogate Branch," must be received by the Joint Secretaries, London and North Eastern Railway, Marylebone Station, London, N.W. 1, by Nine a.m., Thursday, October 25th.
The Directors do not bind themselves to accept the lowest or any Tender.
G. F. THURSTON, }
JAMES McLAREN, } Joint Secretaries.
Marylebone Station,
London, N.W.1,
11th October, 1923 B 891

CHEADLE AND GATLEY URBAN DISTRICT COUNCIL.

ELECTRICITY SCHEME.

The Cheadle and Gatley Urban District Council invite

Tenders for the Supply of

GAS-FILLED METAL FILAMENT LAMPS for Street lighting. Specification and Form of Tender may be obtained by British makers without payment of deposit from Mr. C. H. Wordingham, C.B.E., M.Inst.C.E., M.Inst.E.E., either at 7, Victoria Street, Westminster, S.W.1; or 33, Brazennose Street, Manchester.
Tenders, enclosed in an envelope sealed with wax and clearly endorsed "Tender for Lamps for Street-lighting" must be addressed to the undersigned at the Council Offices, Cheadle, Cheshire, and be delivered not later Ten a.m. on Thursday, 25th October, 1923.
The Council does not bind itself to accept the lowest or any Tender.
By Order,
JOHN H. JOHNSON,
Council Offices, Clerk to the Council.
CHEADLE, Cheshire. B 889

THE METROPOLITAN ASYLUMS BOARD invite separate

Tenders for:—

(A) The SUPPLY and DELIVERY of KITCHEN FITTINGS and APPLIANCES at Tooting Bec Mental Hospital, Tooting, S.W. 17.
(B) The INSTALLATION of a NEW 20-ton WEIGHBRIDGE at the North-Western Fever Hospital, Lawn Road, Hampstead, N.W.3.
(C) The INSTALLATION of a STEAM-HEATED "Decouston" IRONING MACHINE at the Colindale Hospital, Hendon, N.W. 9.

Each in accordance with Specification and Drawing prepared by Mr. T. Cooper, M.Inst.C.E., M.I. Mech.E., Engineer in-Chief. The Specification, drawing, and form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4, on and after Ten a.m. on Saturday, 20th October, 1923, and can then be obtained upon payment of a deposit of £1 in respect of each work. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification, and the Drawing have been returned.
Tenders, addressed as noted on the form, must be delivered at the Office of the Board not later than 2.30 p.m. on Wednesday, 7th November, 1923.
(By Order) G. A. POWELL,
Clerk to the Board. B 900

Tenders are Required in Cairo

not later than Noon on the 31st December, 1923, by the Ministry of Public Works, Mechanical Department, for the supply of a STEAMER for the Upper White Nile Division.—Specifications can be obtained from the INSPECTING ENGINEER Egyptian and Sudan Governments, Queen Anne's Chambers, Westminster, S.W.1. on payment of 5s. 1d. B 836

THE BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for:—

94 Tons WROUGHT IRON, Grades "A" and "C."
Specification and Form of Tender can be obtained at the Company's Offices, 13, Gresham House, Old Broad Street, London, E.C. 2, on or after 15th October, 1923.
A fee of 10s. will be charged for the Specification, which is NOT returnable.
Tenders must be submitted not later than NOON, on Monday, 22nd October, 1923.
The Directors do not bind themselves to accept the lowest or any Tender.
By Order of the Board,
R. C. VOLKERS,
Secretary. B 906

BALLINASLOE MENTAL HOSPITAL.

SUCTION GAS PLANT.

The Committee of Management of above Institution will at its meeting on Monday, the 12th day of November, 1923, consider

Tenders for Supplying and

ERECTING a SUCTION GAS PLANT to suit a 35 H.P. Crossley Gas Engine.
Contractors to furnish complete specification with dimensions.
Tenders, marked "Suction Gas Plant," addressed to the Resident Medical Superintendent, to be lodged not later than Friday, the 9th day of November, 1923.
The lowest or any Tender not necessarily accepted.
By Order of the Committee,
JOHN MILLS,
Resident Medical Superintendent.
8th October, 1923. B 929

STATE ELECTRICITY COMMISSION OF VICTORIA.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY etc., of the following for the Morwell Power Scheme,
Copies of Tender Form and Specification will be available upon application to:—
THE AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C.2.
Specification No. 23/145—4 only 1,000 K.V.A. SINGLE PHASE TRANSFORMERS & SPARES.
Charge:—10s. for the first two copies of Tender Form, Conditions of Contract and Specification complete. This charge will be returned on receipt of a *bona fide* Tender. A third copy and any further copies will be supplied for the sum of 5s. each. This charge is not returnable.
Preliminary Deposit:—A Preliminary Deposit of £25 is to be lodged with Tender.
The Specification may be inspected at the above-mentioned office.
The Commission does not bind itself to accept the lowest or any Tender.
Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned, in Melbourne, not later than Noon, 15th December, 1923.
R. LIDDELOW,
Secretary,
State Electricity Commission of Victoria,
Melbourne, Victoria,
Australia. B 845

APPOINTMENTS OPEN.

General Manager Wanted for

Engineering Firm in Aberdeen, producing Conveying and Elevating Plants, Grinding Machinery, etc. Specialists in Gearing and all kinds of Pulleys, also Millwright Work. Applicants must be Qualified Engineers, experienced in all branches of the Firm's Manufactures, and accustomed to negotiating commercial contracts.—Address, stating age, qualifications, experience, and salary expected to WATT & CUMINE, Advocates, 8, Golden Square, Aberdeen. B 857

Works Manager for

Electrical Switch and Control Gear Factory, with executive and organising ability, and sound experience of modern production methods and processes essential. Good all-round electrical knowledge an advantage.—Write, fullest particulars, salary, age, BOX 551, SELLS, Fleet Street, E.C.4. B 916

Inspector of Works Required,

experienced in tunnel construction under heavy air pressure. State age and salary required and give full particulars of experience.—Address, B 901, Offices of ENGINEERING.

Fuel Officer Required by the

National Federation of Iron and Steel Manufacturers, being a Metallurgical Chemist with practical iron and steel works experience, to devote himself to the examination of fuel problems. A working knowledge of French and German essential. —Apply, giving full particulars of age, education, training and experience, with dates, salary required, etc., to the DIRECTOR, National Federation of Iron and Steel Manufacturers, Caxton House East, Westminster, S.W.1. B 932

The Royal Air Force

REQUIRES SKILLED FITTERS General (for training as Aero Engine Fitters), Fitters Driver Petrol, Electrical Fitters and Power Station tradesmen. Age limits:—Ex-Service men 18 to 30; Non-Ex-Service 18 to 26; highly skilled Fitters up to 35. Ex-N.C.O's up to 38 years (with rank according to trade ability). Pay from 21s. to 66s. 6d. per week, on enlistment, and all found. Allowance for wife and children to men 26 and over.—Write, stating age, or call:—INSPECTOR OF RECRUITING, R.A.F., 4, Henrietta Street, Covent Garden, W.C. 2. B 759

Wanted, Several Good

MACHINE TOOL MAKERS. Men accustomed to setting up and running Automatic Screw Machines preferred. Must be accustomed to working to fine limits. Full particulars must be given.—Address, TOOL, Wm. Portelous & Co., Advertising Agents, Glasgow. B 771

The British Reinforced

CONCRETE ENGINEERING CO., LTD., REQUIRE the SERVICES of a FIRST-CLASS COMMERCIAL MAN as assistant to Managing Director; must be thoroughly competent to control the organisation of large staff. For the position offered, thorough knowledge of constructional engineering is essential. Applicants to state age, previous experience, and salary required.—Letters to be marked "confidential," and addressed to The MANAGING DIRECTOR, The British Reinforced Concrete Engineering Co., Ltd., 1, Dickinson St., Manchester. B 903

Electrical Engineer.—Young

Man Wanted with expert knowledge of small Generators. Position offers excellent prospects.—B 908, giving qualifications, Offices of ENGINEERING.

Required, Chief Assistant

ENGINEER to the Chief Engineer of large railway operating in Spanish-speaking South America; good Climate; must be fully qualified and must have had experience mainten ance and construction. Salary £1200 per annum. Applicants should not be more than 35 years of age.—Applications, which will be considered confidential, should be sent with full particulars and copies of testimonials to BOX C.A.E., c/o Davies & Co., 95, Bishopsgate, E.C.2. B 911

Assistant Engineer

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THE EFFECT OF SCRATCHES AND OF VARIOUS WORKSHOP FINISHES UPON THE FATIGUE STRENGTH OF STEEL.

By W. Norman Thomas, M.A., D.Phil., M.Sc., Assoc.M.Inst.C.E.

(*Concluded from page* 452.)

Scratches and Grooves Resulting from Various Workshop Processes.

Having now obtained some experimental data as to the effect upon the fatigue strength of small scratches of known shape, an investigation was made of the scratches left in practice after various workshop operations. The materials used were tool steel, 0·33 per cent. C steel, 0·13 per cent. C steel, aluminium and cast-iron. Gelatine casts were taken of numerous surfaces after various workshop processes, and reproductions from a small selection of the photographs are appended. In some cases the samples were specially prepared for the purposes of the investigation, while in other cases the casts were taken from ordinary samples.

On account of the irregularity of the surfaces and of the differences found between two specimens of the same class of work, it is very difficult to predict exactly the probable effect upon the fatigue strength of any one type of finish. A few figures are, however, given below which may furnish some rough indication of the maximum effect that might be expected. The 72 deg. V-curve has been taken as the guide, as this closely agrees theoretically with the semi-elliptical groove (*cf.* curves D and E).

Turned Finish.—Examples of tool marks left after "turning" are shown in the photographs reproduced in Figs. 16 to 18.

It will be noticed that in practically every case, the groove is very shallow and moderately smooth—i.e., the material has not been torn badly. The cast-iron surfaces were generally rather rough, causing the gelatine to stick, and making the taking of reliable casts difficult (see Fig. 18).

The depths of the grooves are comparable with those of the smaller experimental scratches, the deepest examined (Fig. 16) being 0·0017 in. deep. The value of $\frac{d}{\rho}$ is usually small, *e.g.*, in the groove in Fig. 16 $\frac{d}{\rho} = 0{\cdot}32$. In most of the other grooves $\frac{d}{\rho}$ has a still lower value. The maximum value found for $\frac{d}{\rho}$ was 0·7, and this would indicate a possible percentage decrease in strength of about 12 per cent. The usual figure would be about half this amount, particularly as—according to theory*—a uniform series of grooves produces a less marked effect than an isolated groove.

Filed Finishes.—Various file marks are shown in the photographs reproduced in Figs. 19 to 22, and it will be seen that the grooves are very irregular in size and shape. The photographs show some of the largest scratches found. In many cases the material seems to have been badly torn (Fig. 19). In the left-hand groove of this photograph, the depth is about 0·00085 in., and the value of $\frac{d}{\rho}$ nearly 2. Similarly the right-hand groove in Fig. 20 has a value of $\frac{d}{\rho}$ rather greater than 1, the depth being 0·0014 in. The maximum effect of such grooves is thus probably larger than the more even tool marks left after machining. The groove having the value of $\frac{d}{\rho} = 2$ would possibly cause a decrease in the fatigue strength of roughly 18 per cent. to 20 per cent. Like the coarse file, the bastard file also produces some very large and irregular grooves, one of the largest giving a value of $\frac{d}{\rho} = 0{\cdot}8$ to 1, with a depth of about 0·0008. The corresponding decrease in strength would be about 14 per cent. The greatest depth noted was 0·0014 in., but the value of $\frac{d}{\rho}$ was comparatively low. The smooth file marks are also very irregular, but much smaller in size. The maximum depth of groove observed was about 0·0008 in. The maximum value of $\frac{d}{\rho}$ was about 1, the depth then being 0·0004 in. Calculating the loss of strength by the approximate rule derived later, *i.e.*, percentage decrease in strength $= \frac{2d\sqrt{\frac{d}{\rho}}}{1+0{\cdot}02d\sqrt{\frac{d}{\rho}}}$, where d and ρ are both measured in inches $\times 10^{-4}$, this decrease may be estimated as $7\frac{1}{2}$ per cent.

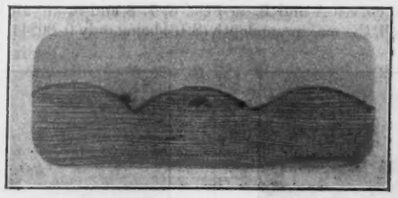


Fig. 16. 0·33 C. Steel. Tool Marks. × 100.

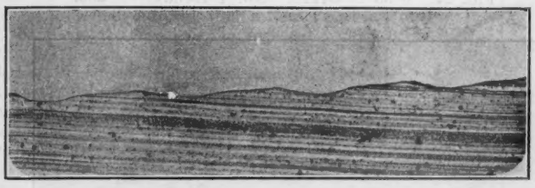


Fig. 17. Aluminium. Tool Marks. × 120.

Fig. 18. Cast Iron. Tool Marks. × 360.

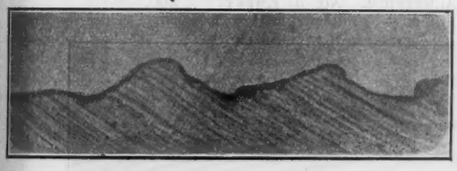


Fig. 19. 0·33 C. Steel. Coarse File. × 300.

Fig. 20. 0·33 C. Steel. Coarse File. × 100.

Fig. 21. 0·33 C. Steel. Bastard File. × 100.

Fig. 22. 0·13 C. Steel. 2nd Cut File. × 100.

Various Emery Finishes are shown in the photographs reproduced in Figs. 23 to 26 on page 484. The surfaces are again very irregular, and the occurrence of isolated scratches of considerably greater magnitude than the average is a characteristic feature. The tearing action is again very marked in some of the examples, *e.g.*, in the case of aluminium Fig. 26. The value of $\frac{d}{\rho}$ in the left hand groove in the latter print must be high—probably over 4, while the depth is about 0·0008 in.

If the results previously obtained are applicable to the new material, this scratch would produce a decrease in strength of about 23 per cent. Limiting the observations, however, to the mild steel samples, the maximum depth of scratch observed with a No. 3 emery was about 0·00045 in., the value of $\frac{d}{\rho}$ being 0·5. The corresponding decrease in strength might thus be as large as 6 per cent.

The smaller scratches have often a greater value of $\frac{d}{\rho}$, at least 1 in some cases, but the estimated effect of these would not be more than 3 per cent. or 4 per cent.

No. 1 emery in a similar manner gives scratches which may be as deep as 0·0003 in., with a value of $\frac{d}{\rho} = 0{\cdot}5$, or less deep scratches with rather higher values of $\frac{d}{\rho}$ not greater than 1. The maximum effect is estimated not greater than about 4 per cent.

In the case of the finer emery grades, such as Nos. O or FF, the depths of the scratches do not exceed about 0·00015 in., and the value of $\frac{d}{\rho}$ does not exceed 1, so that the loss of strength should not be greater than, say, 2 per cent. to 3 per cent.

Carborundum Finish.—The carborundum finishes examined seem to give scratches of the same order of magnitude as these fine emery grades (see Fig. 27).

Ground Finish.—In the specimens of a ground finish that were examined, some of the grooves (in tool steel) were as deep as 0·0002 in. or slightly more, but the reduction in strength would be again only a few per cent.—say, 4 per cent. maximum. An example of reamered finish is illustrated in Fig. 28.

Accidental Scratches.—A considerable number of accidental scratches were examined, but in most cases the values of $\frac{d}{\rho}$ were extremely small. Fig. 29 shows a scratch found upon one of the discs of a fatigue testing machine (coarse ground finish). The depth of the groove is about 0·0012 in. and the ratio $\frac{d}{\rho}$ roughly 0·3. The decrease in strength due to this might be, say, 8 per cent.

Fig. 30 shows an accidental scratch found upon the connecting rod of an oil engine. Here $d = 0{\cdot}0008$ in. and $\frac{d}{\rho}$ about 1·5. The corresponding decrease in strength might be estimated at 16 per cent.

The results thus deduced may be summarised in the following table—they are not intended, of course,

* "The Effect of Surface Scratches on the Strength of Shafts and other Members." A. A. Griffith. Advisory Committee for Aeronautics, Report T. 1,275, December, 1918. B. 2g. "Strength and Design—General 35."

to be exact values—but they are put forward merely as a rough indication of the maximum effect to be expected from the various finishes.

Type of Finish.	Estimated Maximum Reduction in the Fatigue Strength. Per Cent.
Turned	12
Coarse file	18 to 20
Bastard file	14
Smooth file	7½
Coarse emery (No. 3) ...	6
No. 1 emery	4
Finer emery (O or FF) ...	2 or 3
Fine carborundum	2 or 3
Fine ground finish	4
Accidental Scratches (maximum found)	16

Discrepancy between Theoretical and Experimental Results.—It will be seen from the foregoing results that there is a very marked discrepancy between the theoretical and experimental results. Such a discrepancy has for some time been suspected, and Dr. A. A. Griffith has advanced certain theories to account for this.

His two main explanations are given briefly below.

(1) *Scale Effect.*—Dr. Griffith* states that the experimental strength of metals is very much less than the theoretical strength calculated from other physical properties. This difference, he suggests, is due to minute flaws or cracks in the material, and he has confirmed his theory by some very interesting experiments on silica and glass. If the experimental scratches are of such a size as to be comparable with the cracks already existing, their effect will be small, and it will only be with large-size grooves that the theoretical loss of strength will be approached.

(2) *Redistribution of Stresses due to Cleavage Slipping in the Material or to Plastic Flow.*—The comparisons made in the previous pages between the nominal stress and the limiting fatigue stress assume a linear distribution of stress varying from 0 at the neutral axis of the bar, to a maximum in the outside fibres. Any redistribution of the stresses makes the deductions invalid, and it becomes impossible to make any direct comparison between the two figures.

Referring to this question of redistribution, Dr. Griffith states that "in the case of fatigue fractures . . . it may be regarded as probable that redistribution of stress due to cleavage slipping often occurs under ranges of stress within the fatigue limits of the material."

He further states that though "it may be regarded as proved that, in many metals, no important plastic flow occurs within the fatigue limits of stress, under an applied load alternating between numerically equal $+^{ve}$ and $-^{ve}$ values," yet "in some metals, some recent experiments suggest that plastic flow may be met with even under a pure alternating stress." As pointed out by Dr. Griffith also, if appreciable plastic flow does occur, the material must be in a cold worked condition, and increased resistance to fatigue would result.

Scale Effect.—The experimental scratches for the two curves A and B, in Figs. 6, 7, 8 and 9, are all small, the maximum depth (S.16) being only 0·00244 in., and from these alone no very definite information could be gleaned as to the effect of size. To test whether any scale effect was apparent, five additional specimens were tested—the results being plotted in Figs. 6 to 9, page 450 *ante*. The depths of the grooves in these examples are considerably greater than before, ranging from 0·0051 in. to 0·0448 in. It will be seen that their effect upon the fatigue strength is much more marked than in the case of the smaller scratches.

The values of the coefficient c in the expression $\frac{R - R_1}{R_1} = c\sqrt{\frac{d}{\rho}}$ are given in the next column.

Specimen.	Depth in Inches.	Radius of Curvature in Inches.	c.
S. 24	0·0051	0·0035	0·477
S. 25	0·0094	0·0045	0·46
S. 26	0·0173	0·00417	0·475
S. 27	0·0301	0·00417	0·420
S. 28	0·0448	0·0050	0·266

Neglecting the last point, which seems abnormally low in comparison with the remainder, the mean value of c is about 0·46. There does not seem to be any appreciable scale effect within this range, *i.e.*, beyond a depth of 0·005 in., or a radius of 0·004 in. Values of c are plotted against values of the depth of groove d, given in Fig. 10 on page 450 *ante*, and though the curve which is drawn can only be considered as very approximate, it was not thought to be sufficiently important, for the purposes of this paper, to carry the investigation further. In dealing with the scratches left by the finer emery papers, &c., it would appear that the line O a indicates the maximum value of c for these small radii; c may thus be taken as 200 d, where d is the depth in inches.

In estimating the effects of the minute scratches left after some of the finer workshop finishing processes, the reduction in strength can either be first deduced from curve B, Fig. 9, and this result modified by adopting a value of $c = 200\ d$ instead of $c = 0{\cdot}155$, the average value for that curve, or preferably the result may be calculated directly from the dimensions. It may easily be shown that the reduction in strength, expressed as a percentage of the original strength, is

$$\frac{100\ c\sqrt{\frac{d}{\rho}}}{1 + c\sqrt{\frac{d}{\rho}}}$$

If d and ρ are both measured in inches $\times 10^{-4}$

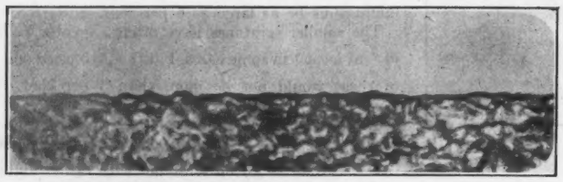


Fig. 23. 0·33 C. Steel. No. F.F. Emery. × 360.

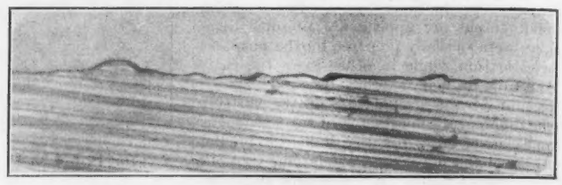


Fig. 24. 0·33 C. Steel. No. 1 Emery. × 360.

Fig. 25. 0·33 C. Steel. No. 1½ Emery. × 360.

Fig. 26. Aluminium. No. 3. Emery. × 360.

Fig. 27. 0·33 C. Steel. Carborundum Finish. × 360.

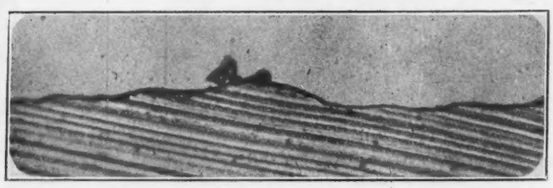


Fig. 28. 0·33 C. Steel. Reamered. × 360.

Fig. 29. Accidental Scratch. × 120.

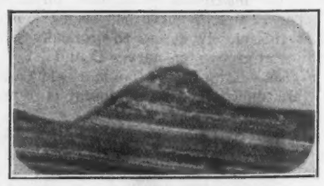


Fig. 30. Accidental Scratch. × 360.

* "Stress Concentrations in Theory and Practice," Dr. A. A. Griffith, B. A. Report, 1921, page 316.

this expression reduces to

$$\frac{2d\sqrt{\frac{d}{\rho}}}{1+0{\cdot}02\,d\sqrt{\frac{d}{\rho}}}$$

It may be noted here, that while the experimental scratches in the first experiments are comparable with the scratches which remain after various workshop processes and with accidental scratches found in practice, the larger grooves are more comparable with small Whitworth screw threads. For these threads the value of $\frac{d}{\rho}$ is 4·67, so that the reduction in strength that might be expected from a single small screw thread is about 50 per cent.

The results in the experiments of Dr. Stanton and Mr. Bairstow, mentioned later, show a reduction of 30 per cent., for test-pieces screw-cut with a continuous thread.

Redistribution of Stresses During the Tests.—In the preliminary tests of the present research, a few experiments were made to see whether the effect of a scratch could be detected by the deflection method. An adjustable mirror was fixed to the free end of the specimen in lieu of the large-headed screw which keeps in its place the ball bearing at the top of the weight-carrier rod. A beam of light was projected on to this from a Nernst burner, and the image of a fine hair line focussed on to a scale. As the revolving specimen was loaded, the deflection corresponding to each load was noted, and these deflections were then plotted against stress as in Fig. 31. The divergence from the straight line occurs at about 15 tons per square inch, which is rather lower than might be expected from the fatigue tests to destruction. The effect of the scratch was barely distinguishable, and so indefinite as to render the deflection method useless for the purpose of the investigation. The chief point of interest, however is the suggestion of some form of stress redistribution before failure. The specimen—which was of the hollow form—was loaded step by step, and subjected to approximately 6,000,000 revolutions at each load. The scale reading was noted at each step, and the results are plotted in curve G, Fig. 31.

When the specimen was first loaded to a stress of about 17·35 tons per square inch, the scale reading was 79 mm. This deflection, instead of remaining steady as at the previous loads, gradually increased until at 2·75 million revolutions it was, 81 mm. At 6·08 million revolutions it was 83 mm. and at 7·225 million revolutions it was apparently the same. These results are plotted in Fig. 32.

To test whether the material was yielding, or whether the zero had changed from some unsuspected cause, the load was gradually removed, and the readings taken while unloading are shown in curve H, Fig. 31. The zero does not quite coincide with the original zero, but the discrepancy is small. It appears, therefore, that the material had definitely yielded under a stress of 17·35 tons per square inch.

On reloading, the curve H was followed—an apparent decrease in the value of E being indicated. The load was now increased, and the specimen failed after 0·573 million revolutions with a stress of 17·77 tons per square inch.

Previously Published Experimental Results.—Though it has not been possible to make any very strict comparison with the results of fatigue tests carried out under other conditions by previous investigators, the general conclusions arrived at in the present paper appear to be confirmed by such other experimental evidence as is available.

The following papers may be referred to :—

(1) "The Endurance of Metals," E. M. Eden, W. N. Rose, and F. L. Cunningham, Proc. Inst.Mech.E., 1911, page 839.

(2) "The Effect on the Resistance to Fatigue of Crankshafts of a Variation on the Radius of Curvature of Fillets." T. E. Stanton and R. G. C. Batson. Advisory Committee for Aeronautics, Internal-Combustion Engine Sub-Committee Reports No. 15, October, 1917.

(3) "On the Resistance of Iron and Steel to Reversals of Direct Stress." T. E. Stanton and L. Bairstow. Proc. Inst.C.E., vol. clxvi, 1905–6, page 78.

(4) "The Effect of Surface Scratches on the Strength of Shafts and other Members." A. A. Griffith. Advisory Committee for Aeronautics, Report T 1,275, December, 1918.

(5) "The Influence of Rivet Holes on the Strength and Endurance of Steel Structures." J. S. Wilson and B. P. Haigh. Section G, British Association, 1922.

(6) "Experiments on the Fatigue of Brasses." B. P. Haigh, Journal of the Institute of Metals, No. 2, 1917, vol. xviii.

(7) "The Effect of Keyways on the Strength and Stiffness of Shafts subjected to Torsional Stresses." H. Gough, Report to the Materials and Chemistry Sub-Committee of the Aeronautical Research Committee.

Summary.—(1) The fatigue strength of steel is lowered considerably by the presence of scratches and grooves upon the surface, but to a very much less extent than is indicated by theory. Thus small grooves from 0·001 in. to 0·0025 in. deep may reduce the strength as much as 30 per cent., and larger grooves 0·01 in. or more deep as much as 55 per cent.—compared with a theoretical reduction of about 85 per cent.

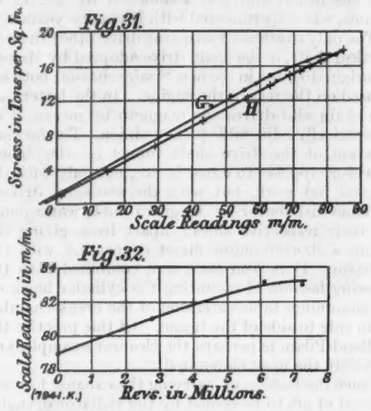
(2) The ratio of the increase of stress to the original stress can only be considered as proportional to $\sqrt{\frac{d}{\rho}}$ as theory suggests, if the variation in the depth is small, or possibly if the depth is greater than some limiting value.

Most of the scratches and grooves found in practice resulting from various workshop processes and from accidental causes, are very shallow, and have a low value of $\frac{d}{\rho}$. These scratches are of the same order of magnitude as the smaller forms of the experimental scratches.

The larger experimental grooves are of the same order as small screw threads.

The estimated effects of various workshop finishes, &c., are tabulated above. In no case does this exceed about 20 per cent., and for most operations is considerably less.

In conclusion, I wish to thank Professor C. F. Jenkin for the interest he has taken in the research, and for his valuable suggestions, criticisms and advice.



THE PARIS AUTO-SALON.

THIS year's Salon de l'Automobile, which, as the eighteenth exhibition of the French automobile industry, opened on Thursday, the 4th inst., has not only already proved the most successful on record, but contains many new expressions of automobile technique. This is not to say that the general conception and component arrangement does not actually remain as heretofore; nor that there are any drastic changes either reactionary or otherwise; such as, for instance, a recently-produced German car, with its six-cylinder broad-arrow type motor placed rearwardly in the chassis. Nor, whatever the forthcoming exhibition of commercial vehicles may disclose, has this Salon given the least indication that French designers are at all disposed to consider front-wheel transmission—with or without the conventional rearward drive—for passenger cars, despite its known advantages of lessening or eliminating skidding and its more effective traction; to say nothing of the comparative success of one of the earliest Spyker models, or that of the Krieger electromobile of a later date. On the other hand, if a single example may be said to indicate a tendency, the 2-litre Sizaire—in which axles are replaced by transverse springs—like the more expensively-designed, but absolutely axle-less 12-h.p. Beck chassis of two years ago, shows a trend towards elimination, that has not yet been equalled in the simplest manifestations of Italian or British practice.

On the contrary, while suspension in general still remains a backward branch of automobile design, the adoption of front wheel braking has been so rapid and general, that its varied applications almost represent a new branch of study in themselves, while detail refinements have been greatly elaborated. Granted the exceptionality of the example, there is as great a difference in quality between the 2-litre Rolland Pilain or La Buire of this year's model, and the average of its size and power-class also exhibited, as there is between a Lanchester or Napier and some ordinary quantity product of American industry, or of our own. Yet the price is so little higher, relatively to the practical value embodied, that one can only ascribe the clearly evident difference to sheer skill in detail design.

Nevertheless, it must be admitted that this external beauty of design, in too many instances, still masks certain essential defects. These are not in general defects of material or workmanship. Nor, apparently, are they operative, as for instance, badly located or inadjustable pedals, unhandy control levers, or vital adjustment points hopelessly inaccessible. They are, on the other hand, such as betray the willingness to risk a certain chance of road failure, because of the general reliability of certain details. Thus in the fundamental matter of valves, although Bugatti in earlier models, Temporino and others, have shown how valves may be mounted so as to be individually detachable for replacement, without caging and its defect of unequal cooling, the sole remaining exponent of this practice, in the "overhead" division is the Majola, while the Mathis and the Zebre—the latter, one understands, redesigned by an English firm of consulting engineers—are the only two examples of lateral valve mounting that still retain valve caps.

The remainder, overheads and laterals alike, cannot have a stuck valve extracted without a protracted job of lifting the entire head block after dismantling its connections; despite the almost even chance that the owner mechanic will not make a perfect refit of the gasket, or that the gasket thickness will vary, resulting possibly in a lessened compression and power output. Nor can any advantage be cited. Not even the direct action of the cam upon overhead valve cotter plate is as mathematically correct for direct vertical thrust, as the laterally toothed-sector motion of the 2-litre Green engine recently shown at Olympia, which still leaves the valve as readily dismountable as ever. Even the ingenious valve-mounting of the new Sizaire—in which the springs are triplicated on two detachable stem-pieces, united by a bridge-plate under the cotter of the valve stem, which acts as an adjusting medium—leaves the valve itself still undetachable, though the triplication of the springs renders the cam thrust upon the bridge-plate directly vertical, and so lessens the chance of sticking.

This point leads to the consideration of the valveless engine. Panhards—whose sleeve-valve motor is now as much their individual product as Voisin's, or Minerva's or Daimler's development of the original Knight type, have now made the sleeves of a special steel of half the weight of the former cast-iron ones, and fitted three shallow rings to the breech-plug instead of the single deep one; thus enabling the ports to be cut deeper for an even fuller induction and freer exhaust. A twelve-month ago, it is said, the difficulty of lubricating the steel surfaces was overcome, along with the

tendency of steel sleeves to spring back out of round after machining. There are, however, no single-sleeve engines exhibited, now that Piccard-Pictet are understood to have given up automanufacture, and, for the time being, the Burt-McCullum patents are not in automobile use. Also no valveless two-stroke (and the two-stroke idea should connote valvelessness as an essential) appears anywhere except in some of the motor-cycle exhibits. The Cote has not been seen since 1914, and the Thomas, with its reciprocating horizontal barrel valve, has never been put into serious production.

The Benjamin Voiturette exhibit, however, does contain a new make of two-stroke, in two and three-cylinder models, which nevertheless is no more than a clever modification of the old Rêne Legros of twenty years ago. That is, the very long cylinder contains the main Legros-cycle feature of a static compression block screwed into the bottom, and covered by the trunk of the working piston at each outstroke, for the primary compression of the previously-induced charge. But instead of the Legros side rods and rotary distribution barrel, a piston rod is screwed to the working piston, inserted through a gland in the top of the compression block, and again screwed into the top of a small crosshead piston to which a connecting rod is attached. On one side of the motor an aluminium slab-like casting is bolted, containing two automatic non-return valves from the attached carburettor; a gas-storage chamber; and above this a passage, in line with the inlet ports containing two more automatic valves. These last do not open before the exhaust has gone, but are still just as liable as in any other motor with directly-opposed ports, to spill half the charge under forced induction into the exhaust. Altogether the working scheme of the Benjamin two-stroke lends itself to considerable criticism. The engine, however, is a very well made job, its best feature being that a dynamoter is built into the front of the crank chamber with its armature on a crankshaft extension, for starting and lighting.

As to prevailing types from the point of view of horse-power at the Salon, it appears that the position has been much mis-stated, either from superficial impressions, or from other reasons. It is anything but a show of small and moderate-powered cars. There are, it is true, only four "straight eights"—the Panhard, Isotta-Fraschini, the latest Chenard-Walcker, and the Bugatti, beside the Cadillac and Oldsmobile V-types, and the Lincoln "twelve" of the same cylinder arrangement. Many makers are exhibiting and producing as many powerful six-cylinder models as they do of standard four-cylinder models. There are, moreover, just as many firms, such as Farman or Excelsior-Adex specialising upon one powerful six-cylinder *type de luxe*—good for at least 75 h.p.—as those who specialise on a small model, which, as often as not, is overburdened with a cramped four-seater body. Even such a fine little creation as the new Berliet 7-h.p., or the Renault 8-h.p., however special, is still only a sort of side-line to other issues from the same works. Then as to the notable regiment of nominal "tens" and "twelves," admittedly just short of a majority of the exhibits, what are the facts? First, we have the rapidly-growing habit of classifying by litres only, as 1½, 2 or 3; and leaving the actual power result to the owners' driving habit. Secondly, there are few of this class which are not capable of 40 h.p. to 45 h.p., and that could not be depended upon to average 20 h.p. to 25 h.p. at half-throttle or a little over. It is significant that they are not mounted upon very light chassis. And since the limits are soon reached, to the cleverest efficiency-designing, they do not achieve such speeds in competition performance, by any special stripping, or aught except their actual power output. Actually, nothing but exceptional compactness of moulding, and attenuation of internal dimensions, which nothing but block construction could permit, gives these even the appearance of small engines.

For the rest, the latest fashion with the almost universal overhead valve motions—other than the dozen or so, rocker operated, with tappets housed in the block casting—is for the vertical shaft between crank and camshafts to be wholly enclosed in the block, either in front or behind; thus constituting a handy conduit for oil-refilling by way of a capped entry in the camshaft casing, in the first instance, and secondly a chimney for oil-mist to the valve gear. Of this there is always plenty, although forced lubrication to all bearings has come into practically universal use on account of its more positive delivery, and especially owing to the requirements of modern high-speed engines around 2,000 r.p.m., and often capable of 3,500 r.p.m. Actual oil-consumption per horse-power or ton-mile shows a diminution in some cases, and an increase in none. Doubtless the same considerations account for the notable increase in forced water circulation as compared with thermo-syphon. The only air-cooled auto-engine is the S.A.R.A. of last year, with its air-jacket supplied with forced draught from a fan driven from the vertical shaft of the overhead valve gear. This year's model is improved by attaching the air-conduits flexibly to the fan casing by means of rubber cuffs, instead of rigidly as before. Aries shows a small motor with a water-cooled head and a finned body; which system, is neither one thing nor the other, and was abandoned by Mr. F. R. Simms, who experimented with it twenty years ago.

The only overhead valve-gear drive other than by vertical shaft, is the chain drive adopted by Majola, its originator, and in the new Sizaire chassis; both are housed on the rear of the engine. In the latter case the chain also drives the magneto by means of an eccentrically adjustable jockey pinion. The forward location of the drive shaft tunnel in the block, however, appears to agree better, not only with the control rod work, but with the accessory drives; dynamo-distributor or magneto and water-pump on their respective sides; apart from giving the pump a shorter, more direct connection with the radiator. It is seen best, too, combined with the growing fashion of mounting the cylinder block on an aluminium table-extension of the crank-chamber from side to side of the frame. Of this practice the Rolland-Pilain is perhaps the cleanest example, and certainly the most elaborated.

Since the fashion of carrying the exhaust forward instead of aft to be cooled by the radiator draught, and to keep the heat out of the front of the car, was set three years ago by Bellanger, one sees it on several of the more studiously designed models. such as the new Sizaire, the Rochet-Schneider, the Zebre, one of the S.C.A.P. engines designed by M. Louis Jouffret, and one of the Berliet models. Others, again, in the fashion of the larger *modeles de luxe*, such as the Farman, Hispano-Suiza, Voisin, Cottin-Desgouttes and others, compromise upon a centralised exhaust downtake with much advantage; notably again in the Rolland-Pilain, with the downtake surrounded by an air muffle, connected direct through the block to the carburettor on the other side. La Buire and Irat also exemplify this practice. The Zebre British designed induction manifolding is cast in duplicate with one passage to the end cylinders, and a short one to the middle ports, both from a Y-shaped trunk; with the excellent result that in the customary order of valve opening, one cylinder cannot rob the other, as with a single-passage manifold. "Hotspotting" is seen in isolated instances of contiguous induction and exhaust manifolding; but with the departure of lateral valve mounting, transverse induction has also passed; so that the system of overhead valve-mounting, apart from the more efficient combustion chamber it connotes, has certainly simplified coring.

As to transmissions, cone or single-plate clutches are in the great majority. Three or four speed changes are still decided by the designers' theoretical predilections in small models as well as the largest; but universally, it may be said, the gear-box itself is mounted *en bloc* with the engine. Consequently, to avoid the weight and whip of long shafting which is so destructive to gear shaft bearing housings, if not to the bearings themselves, several makers, such as Cottin-Desgouttes, Delage, Chenard-Walcker and others, have adopted the system pioneered four years ago by Hispano-Suiza, with a short torque tube spherically attached to the middle cross member and housing the universal joint. This system is also employed on the smallest exhibit of all, the little Austin Voiturette. Excelsior-Adex and Bianchi alone mount the gear-box integrally with the torque tube. There are no examples of gear-box mounting with the live axle; but on the other hand the only two completely suspended transmissions are those of the new engine and one of the S.L.I.M. models; the latest of the latter and de Bazelaire, having abandoned their classic flotation with a lateral cardan shaft final drive; as also has Chenard-Walcker, despite its manifold advantages.

As to rear-axle design, the one-piece bridge type (erroneously called the "banjo") if not universal, is by far the most popular construction, not only for its strength, but for its rapid assembly and dismounting. The use of a torque tube, however, is far from universal, as a goodly number still carry the propeller shaft naked; and of these, the few who employ Hardy-type joints in the transmission, have much improved their construction. The Zebre, with its counterweighted shaft-end and reinforced spider, is a notable instance. Of the orthodox universals the Ballot semi-marine type, with the ring formations replaced by opposed saucer-shaped bodies bolted together, is the neatest in the show.

Front-wheel braking is the principal feature of the Salon. The exceptions may be counted on the fingers of one hand. The extreme is afforded by Chenard-Walcker's actual abandonment of rear-wheel braking, and employing instead, a huge servo-brake on the transmission, in which the servo-action medium is an anchored steel cable. S.L.I.M. (ex Pilain) offers the widest choice, *i.e.*, no front wheel braking on the newest example, and—in the still standard models with floating transmission—the alternative of their simply-adjusted cable operated braking, and their pneumatic system, both of the last two years. This last, being pneumatic, is the gentlest in action of all, but of course, involves the extra weight and cost of a continuously-run air pump and storage bottle; to say nothing of flexible tube connections, with their inherent defects. These last considerations also apply to the oil-pressure actuation system of the Rolland-Pilain. In this a suspended ball-jointed rock-shaft with a pinion, acts on the racked tail of a little piston housed behind the front axle; which, through a flexible connection, moves a second and smaller piston in the hollow of the steering pin; thus lifting the arm of the cam-stud opening the brake shoes. In the Delage device, on the contrary, which is suspended beneath the gear-box transversely, two larger pistons are separated mechanically in the main body, so that the oil in front of them is the medium for separating smaller pairs of pistons at right angles in the ends of the structure. The tails of these pistons in front, move emerging rocker arms, connected direct to the rocking spindles of the front wheel brakes; but those of the rearward pistons oscillate a layshaft with arms connected to the rearwheel brakes, and linked to the control lever; so that this or the pedal, or both, may operate all four brakes.

These are the exceptional examples. The rest, purely mechanical, are seen in four divisions, of which the chief feature after adjustment facility, is the degree of their exposure to mud. The only two in which the mechanism is wholly enclosed, are the Panhard, and the Fiat; in which latter a drum-like formation beneath the axle end contains an eccentric apparently pushing a short spindle-piece, to directly separate the brake shoes. The second is the Perrot system attached to the frame, retained by those who had it last year, and adopted by those who have embodied front wheel braking hurriedly; while the third, as exemplified by S.L.I.M., Jouffret, Louis Chenard, Buick and others, merely embody direct pull, or rocker operation upon the cam stud, the parts concerned being mounted on the brake-drum plate. The fourth division comprises all the variations of location of the original Isotta-Fraschini method of mounting a crank-armed spindle in the angle of the upcast of the front axle, with a shrouded joint to the cam stub. These spindles one sees variously mounted behind, through, beneath or in front of the axle; and some adopt flexible shafting, composed of concentric, oppositely-wound wire tubing, welded together at the attachment ends. But of all these, Vinot only—with a patented system, multiplying leverages—has embodied the principle of providing for those drivers of light weight and no great strength of leg.

With practically only one exception suspension systems remain identical with last year's manifestations, only three or four firms, such as Lorraine-Dietrich and Renault, mounting the "cantilever" type springs diagonally to the frame member to

avoid tail-swing when cornering. That single exception—which is not only thoroughly original, but incidentally an economical design from the point of view of production—is the new Sizaire Frères chassis; designed by M. Maurice Sizaire, and illustrated in Figs. 1 and 2, subjoined.

In this design, the costly axle component is replaced by two transverse springs, front and rear, which, in two-point suspension, carry a frame only

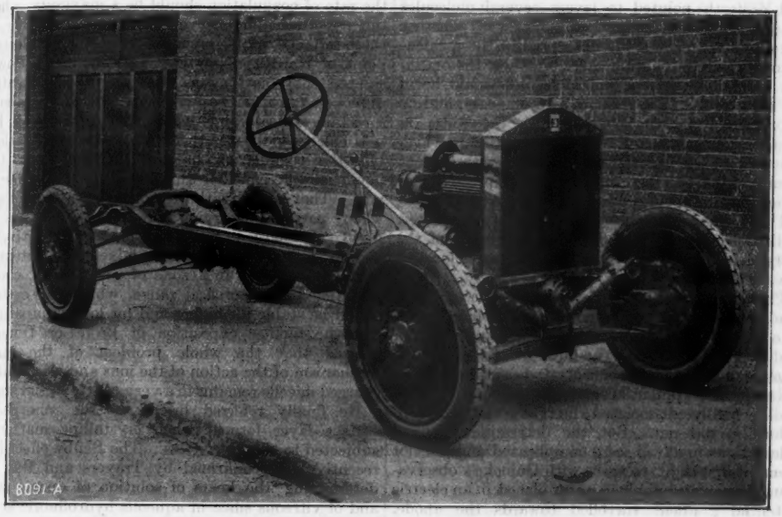


FIG. 1.

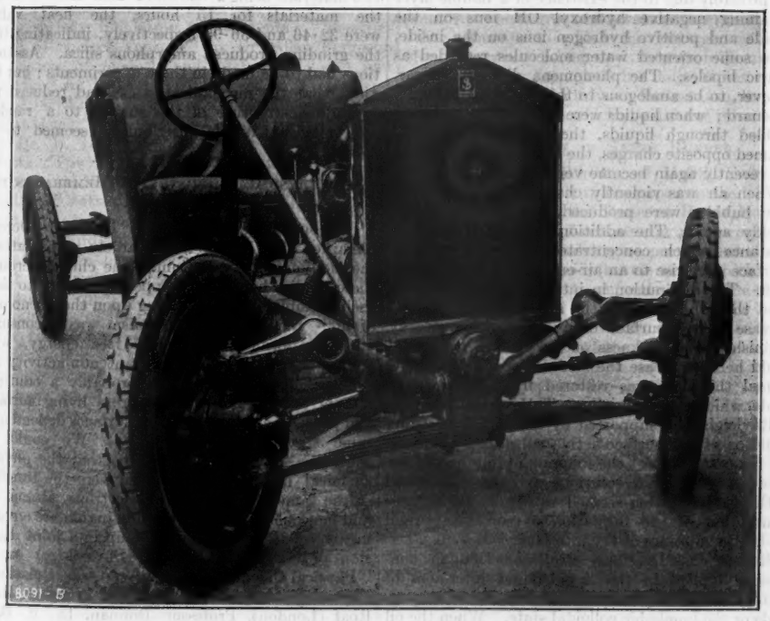


FIG. 2.

FIGS. 1 AND 2. SIZAIRE AXLELESS CHASSIS.

20 in. wide, which for resistance to torsion, has an axial longitudinal steel tube beneath, attached at its ends to the side channel members, thus eliminating cross members. The tubular end members are arched rearwardly, and shaped in an obtuse angle in front, extending outwards from the frame.

The basis of the construction for suspension—indeed, of the whole design—consists of four steering joint forgings, bolted to the brake-drum plates, with their central hub bodies hollowed to contain ball-bearing axle-housings, and the upper and lower portions likewise hollowed vertically, as if for steering joint pins, but actually as grease pots. To these last below, are attached collarwise the plates into which the spring ends are inserted and stud secured. Above, the heads are likewise collared by the union of long shock-absorbers arms disposed < or wish-bone fashion, attached at their functional ends to the extensions of the front tubular member; thus completing the support for the frame, and checking both the rebound, and the roll otherwise to be expected from two-point suspension. With the front wheels thus left free to oscillate for steering and their stub axles rotating in their axial housings in the Wrigley manner, the attachment to the forgings of a three-piece jointed rod, both affords the lightest of rack and pinion steering, and serves as a tie-rod, nevertheless fully adjustable.

Rearwardly the same constructional parts are employed. The axial hub bodies of the forging are drilled through for the cardan shaft transmission, and the shock absorber arms are triplicated N-wise. The attachment of the tail of the N to that extension of the forging to which, in front, the steering connection is attached, holds the wheels in rigid parallel as though axle-mounted. Finally, with this construction reinforced, fore and aft, with flat diagonal stays attached beneath the frame, no torsion can possibly occur upon the springs, either from traction effort behind or road-resistance forward. All four brakes are applied by the direct pull of aero-cable, run through fair heads into the brake drums, and shrouded by wire tubing, in the Bowden manner, but not on that operative principle. The final feature is that chassis lubrication points are reduced to half a dozen, the transmission, the steering and the four grease-pots all claimed to require replenishment but twice a year. The simplification of the design, and the elimination of parts, has reduced the chassis weight to 625 kg. only.

THE BRITISH ASSOCIATION.

(*Continued from page* 454.)

SECTION B.—CHEMISTRY.

SEVERAL of the great problems which occupied Section A came also before the Chemical Section. The joint discussion on "Cohesion and Molecular Forces," on which we commented on page 359 of our issue of September 21, was held in Section B, which afterwards discussed the chemical aspects of the problems of atomic structure and the quantum theory. The presidential address on "The Physical Chemistry of Interfaces," approached the cohesion problems from a special standpoint and led to further discussions, both of chemical and physiological importance. The various other papers—there were 20 altogether—connected more or less with colloids and with cotton and dyeing and other subjects, all fell into line; but there were no communications on the great chemical industries of the Merseyside, though the Section paid visits to several chemical works. The crowded attendances in Professor E. C. C. Baly's lecture theatre, in which the Section deliberated, bore witness to the sustained high standard of the proceedings. The sectional officers were: President, Professor F. G. Donnan, F.R.S., of University College (late of Liverpool); recorder, Professor C. H. Desch (Sheffield), and secretaries Dr. H. McCombie (Cambridge), Dr. E. H. Tripp (London) and Professor I. M. Heilbron (Liverpool).

THE PHYSICAL CHEMISTRY OF INTERFACES.

Though engineers may have looked with some diffidence at the title of Dr. Donnan's presidential address, "Some Aspects of the Physical Chemistry of Interfaces," they found that it dealt with problems which touched them very directly. It is not only chemists, physicists and physiologists who are interested in the phenomena which occur at the surfaces or interfaces separating different sorts of matter in bulk. The importance of these phenomena for the cells of living organisms has no doubt given a great impetus to their study. But Professor Donnan alluded to these features only in his introduction and conclusion, and the modern study of interfacial and transitional layers is based on the work, not of physiologists, but of Willard Gibbs and J. J. Thomson. Physical chemists recognised that in these regions things could happen which would not occur in the more homogeneous regions well inside the volume of matter in bulk. A surface layer represents—as Professor Donnan remarked—a thin cross section which can be probed and examined much more readily than any part of the inside bulk.

In the bulk of liquids, Dr. Donnan said, molecules or atoms probably moved towards each other without any privileged orientation. If special orientation should be characteristic of interfaces, the interfaces should exhibit new phenomena, and if the molecules were ionised or had a bipolar character, electric double layers and potential differences might be set up at the boundaries. In the old theories of Laplace, Gauss and Poisson the field of force surrounding an element or molecule was spatially uniform, and the equipotential surfaces were concentric spheres about a small centre. At present it was believed that the field of force might be small compared to molecular dimensions and might be irregular, parts possessing high "residual chemical affinity" giving rise to powerful regions of force of relatively minute range which could be saturated or neutralised by atoms or groups of neighbouring molecules. According to W. B. Hardy,

the chief pioneer of these newer theories, the equipotential surfaces were not spherical, and the condition of minimal potential involved two terms, the one relating to variation in density, the other to the orientation of the fields of force; the parts of the molecule possessing the most powerful stray fields would be attracted towards the bulk and would cause definite orientation of the whole molecule at the surface.

If A and B were two immiscible liquids, γ_A and γ_B their surface tensions and γ_{AB} the interfacial tension (at the boundary A/B), then the quantity $W = \gamma_A + \gamma_B - \gamma_{AB}$ represented the decrease of free surface energy and therefore the maximum work gained when surfaces A and B were allowed to approach and to touch one another normally at constant temperatures. When two different liquids were taken, B being always water, W depended upon the chemical constitution of A and had high values for atomic groups characteristic of alcohols (CH . OH), acids (CO . OH) and esters (saltlike organic compounds), possessing high residual affinity or local stray fields of electric or electromagnetic forces. On that view cohesional forces would mainly be chemical in origin. The view was supported by the experiments of W. D. Harkins, who found that the "adhesional work" of many organic liquids towards water was much increased by the presence of oxygen atoms as in acids and alcohols, whilst symmetrical compounds like carbon-tetrachloride (of high cohesional work) gave low values of adhesional work towards water. According to Hardy's work on static friction and lubrication, as we passed (by introducing active atomic groups) from hydrocarbons to their alcohols, acids and esters, the coefficient of static friction decreased and the lubricating power increased. Dr. Donnan referred in this connection to the improvement of the lubricating power of hydrocarbon oils by the addition of fatty acids (Wells and Southcomb) and to the experiments by W. E. Garner and Bhatnagar, showing that the interfacial tension between mercury and B.P. Paraffin oil was markedly lowered by small additions of oleic acid, whose molecules were adsorbed or concentrated at the mercury-oil interface, probably owing to the fixation and orientation of their molecules at the interface. This, like many other researches referred to, was carried out in Professor Donnan's laboratory.

As to the investigation by Miss Pockels of the invisible films of olive oil spreading on water, Professor Donnan continued, Rayleigh had observed that the surface tension of the water did not decrease until the film concentration reached a certain very small value—that of a continuous film one molecule in thickness apparently—and that it fell afterwards as the concentration increased up to a certain point, corresponding probably to a layer of a thickness of two molecules; the surface tension then remained unchanged when the film thickness was further increased. The unimolecular layer, the existence of a "two-dimensional phase of matter," was supported by Devaux, Marcelin and Langmuir; the latter suggested that the formation of the unimolecular layer was due to the active groups which were attracted inwards towards the water so that the long open-chain molecules of the fatty acids would be oriented with their long axes vertical, side by side. The measurements by N. K. Adam confirmed the view that the length of this chain or rod, if straight, increased with the number of carbon atoms (or groups), from 21×10^{-8} cm. for myristic acid with 14 carbon atoms to 24 in palmitic acid with 16 carbons, and to 31·4 in behenic acid with 22 carbon atoms, and that the average distance between two adjacent carbons was $1{\cdot}5 \times 10^{-8}$ cm., which was supposed also to be the distance between the carbon centres in diamond crystals. According to the X-ray measurements, however, which A. Müller made on crystals of fatty acids, the lengths of the chain would be a little longer than stated, and the unit cell would consist, not of a single rod, but of two molecules arranged with their long axes parallel on a spiral, which might be straightened out or elastically compressed in a surface film. As regards the bimolecular layer, Dr. Donnan only remarked that the second characteristic point in the surface-tension curve occurred when the molecules of the unimolecular layer had become as tightly packed as possible.

The surface film might also spread by the condensation and absorption of vapours of the oil. The view that this film was unimolecular was supported by T. Iredale's experiments with vapours of methyl acetate on mercury surfaces; but the surface was not quite saturated in the unimolecular sense in these and other experiments; that is to say, less vapour was adsorbed than would correspond to a uniform unimolecular layer, whilst other experiments on glass-wool absorption (by Evans, George and Mülfarth) pointed to layers several molecules thick. There was some doubt, however, whether the simplified formula of Gibbs used in these calculations was strictly applicable; further, the originally insoluble surface film molecules would be in the state of "surface vapours" in one case, and be "hydrated" by the contact with the water in another, and not be quite in the condition in which they were placed in the water. That was evident already from the fact that the uncompressed unimolecular film, placed upon the water from outside, did not affect the surface tension of the water, whilst surface layers of dissolved molecules of the fatty acids and other substances at once lowered the surface tension.

Professor Donnan passed to the electric potential gradients and potential differences in surface layers. The liquid air electric potential changed when additions were made to the liquid; substances like organic acids which concentrated at the surface reduced both potential and the surface tension, whilst highly dissociated inorganic salts (alkali chlorides) did not. But the determinations and calculations involved were complicated and did not seem, at first sight, to agree with Quincke's observation, that an air bubble in water placed in an electric potential gradient travelled towards the anode, that is, it behaved as if it were negatively charged. The potential difference at the air/water interface was probably due to the existence of a double layer containing negative hydroxyl OH ions on the outside and positive hydrogen ions on the inside, or to some oriented water molecules regarded as electric bipoles. The phenomena did not appear, however, to be analogous to the "waterfall effect" of Lenard; when liquids were sprayed or gases were bubbled through liquids, the gas and the liquid assumed opposite charges, the explanations of which had recently again become very doubtful.

When air was violently churned up with water, large bubbles were produced, but they collapsed quickly again. The addition of very little of a substance which concentrated at the air/water interface gave rise to an air-emulsion and a durable froth. The diminution in interfacial tension facilitated the subdivision of the air, while any sudden increase in the surface of a bubble momentarily diminished the thickness of the surface layer and would hence increase the surface tension, until the normal thickness was restored by diffusion from inside, which took some time. This explanation, due to Rayleigh, was supported by the fact that strong solutions of the surface-active substance often did not foam at all. Yet the foaming of liquids like sea water, stout, vapour solutions and the mineralised froth of ore flotation seemed to require the further assumption of the formation of some semi-rigid gel-like membranes at the interface.

Similar considerations, Professor Donnan continued, applied to the liquid/liquid interfaces of two immiscible liquids and the stability of suspensoids or the lyophobic colloidal state. When the oil droplets of water emulsions were watched under the microscope, they were observed to travel in a potential gradient towards the anode as if the oil were negatively charged to about 0·05 volt, and nearly the same potential difference, viz., of 0·055 volt, had been deduced by McTaggart for air bubbles moving in water; the potential difference therefore appeared due to a double layer residing in the surface layer of the water. When hydrochloric acid was gradually added to the water, the potential rapidly fell off; caustic soda first raised, and then, still at very low concentration, also diminished the potential; salts, especially of metals of high valency, had very strong effects and might reverse the sign of the electrification. Taking the chlorides of potassium, barium, aluminium, thorium (metals of valencies 1, 2, 3, 4), the ratio of their effective concentrations was 2,500, 95, 1, 0·135 (taking the effect of aluminium as unit).

But, Professor Donnan proceeded, the particles of emulsions and colloids were in constant Brownian movements; why did they not coalesce when colliding? With respect to other particles at a distance, a double layer would act as a closed system. When two particles penetrated into one another, after colliding, however, a repulsion should be set up between two similarly-charged layers, while the rate of coagulation should be a maximum when the potential difference or the electric density at the interfacial double layer was zero (the iso-electric point of Hardy). Now the experiments of Powis showed that, as long as the interfacial potential difference (whether positive or negative) was above a certain critical value, which was 0·03 volt in his particular conditions, there was little coagulation, but the coagulation became marked when the potential difference fell within that range of ± 0·03 volt. That agreed with previous observations that, when particles carrying opposite charges—*e.g.*, negatively-charged oil droplets and positively-charged ferric hydrosol—were mixed, the potential would fall to zero in a zone of coagulation, corresponding to this critical range, whilst the system would be stable for higher and for lower potentials. Yet the further exposition of Professor Donnan showed that the whole problem of the inner mechanism of the action of the ions and electrically-charged micelle remains in a very controversial state.

He finally referred briefly to the amorphous surface layer formed when crystalline matter is subjected to shearing stress. The Beilby effect had recently been confirmed by Travers and Rây by determining the heats of solution of quartz sand and of vitreous silica in aqueous hydrofluoric acid; the figures found, in kilogramme-calories per gramme molecule, were 30·29 and 37·24, the densities of the two materials being 2·638 and 2·208. After grinding the materials for 15 hours, the heat values were 32·46 and 36·95 respectively, indicating that the grinding produced amorphous silica. Assumptions had to be made in these experiments; but the view, that the mechanical stress had reduced the crystalline structure of the surface to a random molecular or atomic distribution, seemed to be sound.

The Physical Chemistry of Membranes in Physiology.

In concluding his address Professor Donnan remarked that he had dealt largely with states of thermodynamic equilibrium. The chief interest of these studies had always appeared to him to lie in their possible ultimate bearing upon the phenomena of life. But the living organism was a consumer and transformer of external free energy, while environmental equilibrium meant non-activity and eventual death. There was probably a continual flux of activity along and across living surfaces. Did the very existence of these surfaces depend upon some special sort of activity? We could not generalise, but we might assume that the physico-chemical manifestations of life were the functions of the same potentialities of electrons, atoms, ions and molecules which we found in inanimate environments. These problems came up in a joint discussion of Sections B and I (Physiology) on the "Physical Chemistry of Membranes in Relation to Physiological Science," in which Professor H. E. Roaf (London), Professor Donnan, Dr. E. B. R. Prideaux (Nottingham) and others took part. Dr. Prideaux read a paper on "Membrane Potentials Considered as Diffusion Potentials," advocating the view that the membranes allow slow diffusion, and that the membranes potential are due to the selective permeability of anions and kations.

Enzymes.

Dr. E. F. Armstrong, one of the vice-presidents of the Section, introduced his paper on "Enzymes" by the remark that the study of surface effects was probably the most important problem for the near future. Some of the views to which he subsequently gave expression were heretical, but probably sound. Enzymes—popularly known as organised catalysts, of primary importance in fermentation and physiological chemistry—were to be regarded as colloidal catalysts, capable of doing under ordinary con-

ditions in organic reactions what reagents effected at high temperatures. The action of enzymes was mainly hydrolytic; by splitting water up into hydroxyl OH and hydrogen H, or also into hydrogen and oxygen, they could act as oxidising and reducing agents and as synthetisers; water, he added, was the most complicated substance known—possibly, we submit, because it is the best studied. Enzymes could be obtained from animal and vegetable tissues in a concentrated, as opposed to a purified, condition; there was probably no such thing as a pure enzyme; their action took place essentially at solid surfaces, and the phrase "soluble enzyme" was a misnomer. An enzyme behaved as a particulate colloid in extremely fine division, very unstable, *i.e.*, sensitive to outside influences; but in every case its action was restricted to a few substances closely related in structure, and there was intimate correlation between the substrate, *e.g.*, the cell membrane, and of the enzyme complex. Their great activity was due to development of active surfaces; whether the attractive forces coming into play were to be called chemical or physical might be a matter of phraseology, but we had still to form a function of the energy relations.

Dr. K. G. Falk, of New York, followed with a paper on the "Relation of Certain Enzyme Actions to Tissue Differentiation and Tumour Growth." We may also mention a paper by Miss E. S. Semmens on the "Biochemical Effects of Polarised Lights," showing that polarised light broke up starch grains in the presence of very little diastase when ordinary light or darkness had no effect, at any rate, as long as the temperature was below 25 deg. C.

Colloid Chemistry.

The report of the committee on "Colloid Chemistry and its General and Industrial Applications" (Professor F. G. Donnan, chairman; Dr. W. Clayton, secretary) was a summary of six papers. We give the titles, briefly indicating the contents: "Measurement of Surface Tension," by Dr. Allan Ferguson (a review of modern methods); "Collagen and Gelatin," by Professor H. R. Procter, F.R.S., and Dr. J. A. Wilson, of Messrs. A. F. Gallun and Sons, Milwaukee; "Colloid Phenomena in Bacteriology," by Dr. E. Rideal; "Individual Applications of Wetting Power," by Mr. W. H. Nutall, of the Ioco Rubber and Waterproofing Company, Glasgow (the ability of wetting a solid surface, *i.e.*, to cover it with a continuous film, depends upon the surface tensions liquid/air T_1 and solid/air T_2 and the interfacial tension liquid/solid T_3. To wet the solid, T_2 should be greater than $T_1 + T_3$, but the problem is still obscure); "Colloids in relation to the Manufacture of Inks, by Mr. C. A. Mitchell (dealing with iron tannates); and the "Manufacture of Artificial Silk in Relation to Colloid Chemistry," by Mr. Edward Wheeler (referring to the four processes actually in use; namely:—the cuprammonium or Glanzstoff process of Pauli; the nitrocellulose Chardonnet process, the viscose process of Cross and Bevan, and the cellulose acetate process).

The Formation of Precipitates.

Professor Sven Odén, of Stockholm, gave in his paper on "The Formation of Precipitates" an account of the quantitative work which has been done with his balance for studying the formation and settling of precipitates and colloids and evaporation. The apparatus (which we have mentioned on other occasions and which has been modified by Dr. B. A. Keen, of the Rothamsted Experimental Station) and the subject were also brought before the Agricultural Section M, in connection with soil problems. Professor Odén explained that the formation of precipitates in reacting solutions took place in several stages. First molecules and ions united to nuclei or unit cells; these grew, especially in diluted solutions, and formed aggregates of secondary particles analogous to the coagulation of colloids. When the electric charges decreased, aggregation began to take place at a critical point; as the charge went down to zero, the size of the aggregates went on increasing. Yet there was, in reversible aggregates, no amalgamation of the individual particles, and probably no equilisation of the charges, otherwise we could not understand why the addition of certain ions again raised the charge and caused disaggregation.

In the fourth stage irreversible aggregates were formed; these consisting either of definite structure (snow flakes, crystallites, or spherolites) or of irregular shapes assumed under external influences. In the formation of the irreversible aggregates the water envelopes of the particles were broken through, and real contact between crystal surfaces was obtained. The fifth stage was the growth of big crystals at the expense of smaller ones; favourable growth conditions were variability in size and a variation in solubility of the particles with size.

The Activation of Hydrogen in Organic Compounds.

The general interest of a paper of this title by Miss Edith H. Usherwood, of the Imperial College of Science and Technology, South Kensington, lies in the collation of evidence that the tendency of organic compounds to undergo certain reactions can be correlated to definite structural features. The author did not deal with chemical stability problems and reactions from the cohesion standpoint, but we may regard them from that point, and the question deserves consideration by the engineer. In ethane C_2H_6, we have two CH_3 groups joined by their carbon atoms; in methyl iodide we have one iodine atom in the place of the one CH_3 group. Both these compounds are stable; but as we replace the hydrogen atoms more and more by complex radicles the stability of the compound diminishes. The essential feature there is the carbon-carbon bond. But similar relations hold for carbon-hydrogen bonds. Miss Usherwood's "activated" hydrogen is mobile, *i.e.*, it can easily be shifted to other positions or be replaced, and compounds containing activated hydrogen form addition compounds with metals and with unsaturated compounds. The degree of activation depends upon the other elements to which the hydrogen is joined. Miss Usherwood did not speculate upon the ultimate causes of reactions, but her suggestions appear fruitful; they might help us, for instance, to understand "oiliness", to which she did not refer.

The Resin of Hevea Rubber.

Professor G. S. Whitby, of McGill University, Montreal, pointed out in his paper on the "Nature and Significance of the Resin of Hevea Rubber," that the 3 per cent. of resin in raw rubber contained among other products varying proportions of a new fatty unsaturated acid (heveic acid) which had a marked influence on the vulcanisation of the rubber. The introduction of strong bases into the rubber accelerated the vulcanisation with catalysts and increased the strength of the rubber; the bases not only neutralised the acid mentioned, but also dispersed the soaps produced.

Cotton Wax.

The extracts known as cotton wax and, obtained from cotton by means of organic solvents and also of dilute caustic soda may, as Dr. R. G. Fargher explained in his paper on "Cotton Wax" contain in addition to a wax proper, small proportions of a fat and the readily soluble portion of the resin present in the cotton. The wax is welcomed by the spinner inasmuch as it lubricates the material during the preparatory processes and the spinning, whilst the bleacher and finisher want to have the wax removed. The removal is effected by means of scouring in which, Dr. Fargher found, emulsification plays an important part. He described his analytical studies of the extracts obtained by the action of various solvents, giving particulars of the constitution of these waxes as isolated from two American cottons and one Egyptian cotton.

The Absorption of Methylene Blue by Cotton.

The paper of this title, by Dr. D. A. Clibbens, indicated a new method for determining the efficiency of cotton bleaching as applied in the production of pure cellulose. The method is based upon a quantitative investigation of the conditions which determine the absorption of neutral solution of methylene blue hydrochloride by bleached cotton. In the bleaching, Dr. Clibbens explained, the cotton was first scoured with hot diluted caustic alkali to remove the greater portion of the cotton impurities, and the scoured material was then bleached by means of oxidising solutions. The absorption of the blue being a function of certain acidic impurities of cellulose decreased as the bleaching proceeded to a minimum which depended upon the origin and growth environment of the cotton, being much higher for Egyptian than for American cotton. Normal bleaching after scouring would not further affect the absorption, but over-bleaching would. That had been known for some time; but it was not generally recognised that under-scouring would have the same effect. Dr. Clibbens is working at the Shirley Institute for Cotton Research, Manchester.

The Sulphonation and Nitration of Naphthalene.

The communication on the "Sulphonation and Nitration of Naphthalene," made by Professor H. E. Fierz, of Zürich, had—as represented, at any rate—more theoretical than direct technical interest. Sulphonation, *i.e.*, introduction of the sulphuric acid radicle into organic compounds, is very important for the direct or indirect attack of hydrocarbons in the preparation of derivatives, and that applies to nitration as well. With respect to sulphonation, Dr. Fierz supports the rule of Armstrong and Wynne (as to the order in which two or more sulphuric acid radicles enter the naphthalene molecules) and corrects various statements made by previous workers. Dr. Fierz has also investigated more than a hundred sulphonates, and he finds that their crystallographic shape is exclusively determined by the anion, *i.e.*, by the organic radicle, and not by the metal, the cation, and that the free acid and the salt are very similar to one another, as one would expect under this condition. The salts, studied by Dr. Fierz together with P. Weissenbach and A. Hasler, were compounds with the alkali and alkaline earth metals, and with zinc, cadmium cobalt, nickel, lead, and copper, some crystallising in very brilliant colours.

The Chemistry of Hafnium.

The researches of Dr. Coster, which we mentioned in our account of the proceedings of Section A (page 452 *ante*), and of Dr. G. von Hevesy, who read a paper on the "Chemistry of Hafnium" before Section B, seem to leave no doubt as to the elementary character of hafnium and as to its position in the periodic table. When we referred to the new element hafnium on page 180 of our issue of February 9th last, the subject was still largely controversial, and the various statements by Dauvillier, Urbain, Alexander Scott and by Coster and Hevesy (working at Copenhagen) were incompatible. But Dr. Hevesy was able to show several grammes of hafnium salts; he has found that the zirconium extracted from some Norwegian zirconium ores contains up to 30 per cent. of hafnium, which always seems to accompany zirconium in proportions of a few per cent., and it looks indeed as if the element zirconium which Klaproth discovered in 1789, such as known so far, is merely a mixture of zirconium and hafnium. Chemically, Dr. Hevesy stated, hafnium stood between zirconium and thorium, but was much more closely related to the former than to thorium; in fact, it should occupy the place in which cerium had so far been placed. The separation from the potassium double fluorides of the three metals, hafnium, zirconium, thorium, was easy because the hafnium was the most soluble of these compounds; in the double ammonium sulphates hafnium, as the most soluble, passed into the mother liquor. Hafnium was also more basic and its sulphate less easily decomposed by heat (at 500 deg. C. instead of 400 deg.) than the zirconium salt. Thorium salts were generally free from hafnium. The atomic numbers of the three elements are: Zr 40, Hf 72, Th 90; the atomic weights Zr 89·7, Th 230·8; the atomic weight of hafnium Hf has not yet been determined, and we mentioned that Dr. Aston found his new method of anode ray analysis unsatisfactory in the case of zirconium, whilst Dr. Coster's X-ray examination settles the atomic number as 72.

Aluminosilicates.

The paper by Professor W. Vernadsky, a Russian chemist now at Paris, on "Aluminosilicates," has

considerable interest for mineralogists and for the ceramic industry. The aluminium silicates may be simple anhydrides (sillimanite and leverrierite); they may contain fluorine (topaz); they may be acid (kaolinite), or salts (orthoclase), containing mostly alkali or alkaline earths; they all give additional products, and their decomposition by weathering is of great importance to the geologist, the farmer and the technologist, who uses permutits (zeolites) for water softening.

The Utilisation of Volcanic Steam.

Senator Ginori Conti, of Rome, being unable to come to Liverpool, his lecture on "The Utilisation of Volcanic Steam" was not given. The subject, he was going to speak upon, was discussed in an article on "Harnessing a Volcano to a 15,000-h.p. Electric Power Station," which Professor Luigi Luiggi contributed to our issue of November 17, 1916; when he also mentioned Prince Ginori Conti as having first utilised the volcanic steam heat of Tuscany in 1903.

(To be continued.)

LOADING AND UNLOADING DEVICE FOR MOTOR VEHICLES.

There have been many attempts made to devise some system of operation for a motor vehicle service which would reduce the long periods during which the carrying vehicles are idle in the course of the day. It has been thought by some workers in this field that a solution might be obtained by building up the goods on bridges or platforms, in a manner that is becoming increasingly popular within stores and workshops to facilitate interdepartmental transport, and only bring the vehicle to its load when all the goods are stacked ready for removal. Such an arrangement combined with the facility for easily raising the platform and its goods into position has much to recommend it.

An attempt of this character, made by two Swiss engineers, Messrs. Vonnez and Jacquemot, has now been put on the market by the firm of Swiss Berna, Limited, of Short-street, New Cut, Southwark, London. The system of operation and the construction of the gear are shown in the illustrations on the present and opposite pages. The aim is to build up the material, whether it be engineering plant such as is shown in the illustrations, Figs. 1 to 3, cases, packages or loose waste substances, on platforms or in a standard container, back the lorry to the load and raise the latter by means of a haulage gear which is part of the equipment. Working in this way the vehicle would only be occupied on actual transport work and may be used in conveying loads while others are being prepared for later journeys.

Three different constructions are used, each being designed for a particular class of service. Of these the first type of arrangement is that which is depicted in the illustrations. When the load is light the platform is pulled up on to the lorry by the wire rope from the winch situated behind the driver's seat. Should the load be heavy, however, as is the case with the miscellaneous plant shown in Figs. 1 to 3, the removable top of the lorry which is built up of steel sections, is placed under the platform, to which it is gripped, and the two are raised together by the cable from the winch. In the first operation the front of the bridge is raised until the guide rails on its underside rest upon the pulleys or rollers at the back of the lorry. Further movement then causes the loaded bridge to swing into a horizontal position, and it is drawn forward until resting in the proper location. No inclined planes or other gear for handling is thus required apart from that provided on the lorry. The winch drum is movable and so set up that the rope is run off in the centre line of the lorry no matter how much rope is paid out.

The construction of the gear is shown by elevation, plan and sectional views in Figs. 4 to 9. A drive is taken from the engine through a worm to an enclosed worm wheel on the second shaft. This motion is transmitted through spur wheels to the winch shaft. The drum is keyed to tl is shaft, but can move along it to give the proper run for the cable. There is no chance of the wire rope riding on top of the drum, because it is retained in the grooves by the fixed encircling casing. The other end of the rope is passed out from the drum on the underside, and is available to connect to the platform at the winch end, after passing under a pulley below the lorry and over one at the back end of the chassis, for use in drawing off the load when its destination is reached. The operating handles, to put the winch clutch into operation and also for the brake, are situated beside the driver's seats. The movement to put the winch into action is also used to release a catch on the drum which otherwise would prevent it from turning. The movable top of the lorry is shown in Figs. 10 and 11 by an elevation and half-plan. The side hooks upon it are turned down over studs on the side members of the frame of the chassis, to prevent any motion of the platform when the vehicle is running.

In the second type of construction the steel frame which forms the top and back of the lorry is hinged to the rear of the chassis in such a position that when it is tipped the back frame rests upon or is just clear of the ground. When the load is placed upon it the connection from the winch is used to tilt the frame

LOADING AND UNLOADING DEVICE FOR LORRIES.

Fig. 1. Load Mounted on Platform.

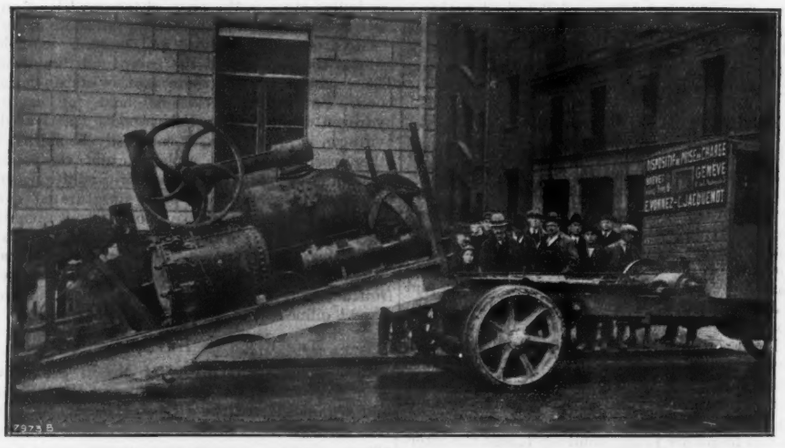


Fig. 2. Raising the Front of the Platform.

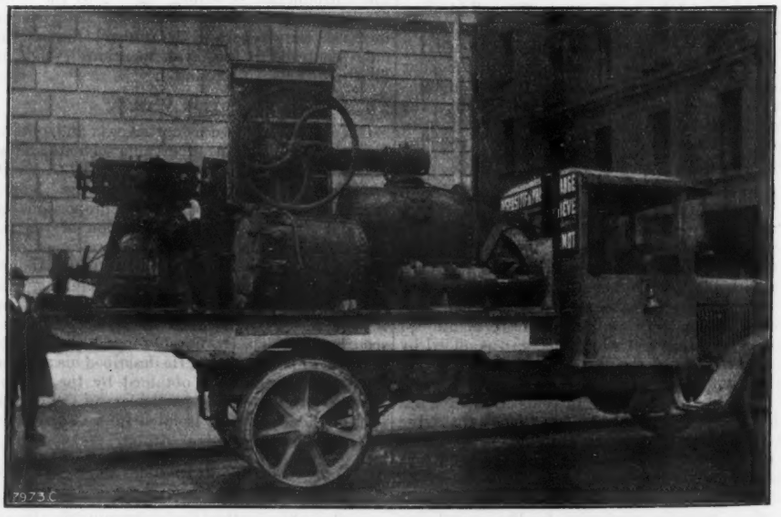


Fig. 3. Platform with Its Load Drawn Into Position.

LOADING AND UNLOADING DEVICE FOR MOTOR LORRIES.

Fig. 4.

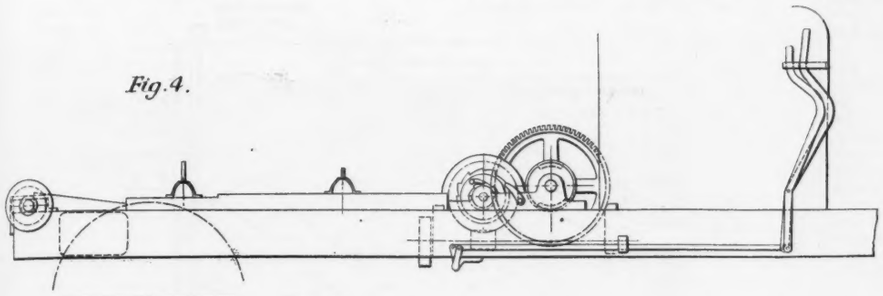


Fig. 7. SECTION ON LINE B. B.

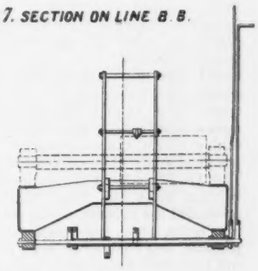


Fig. 5.

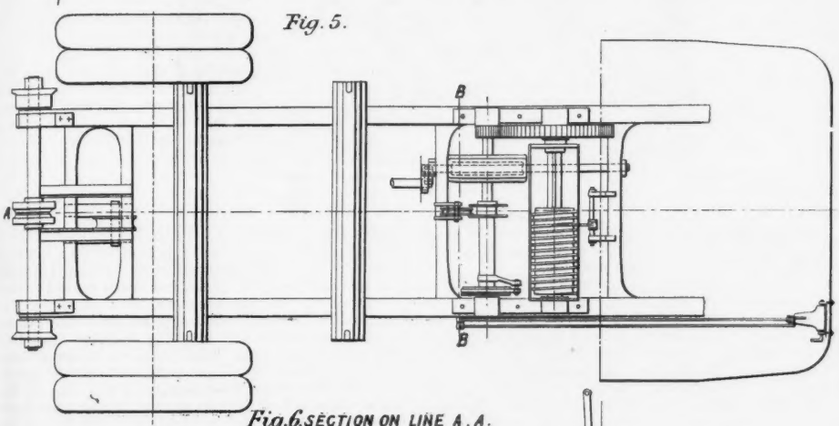


Fig. 8. END VIEW

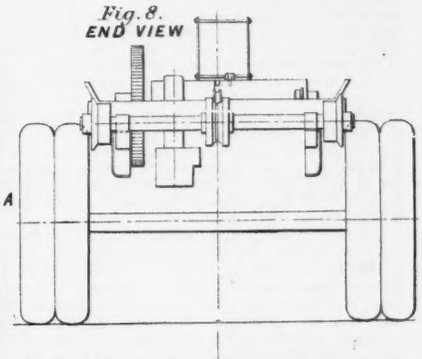


Fig. 9.

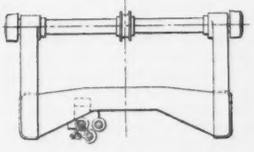
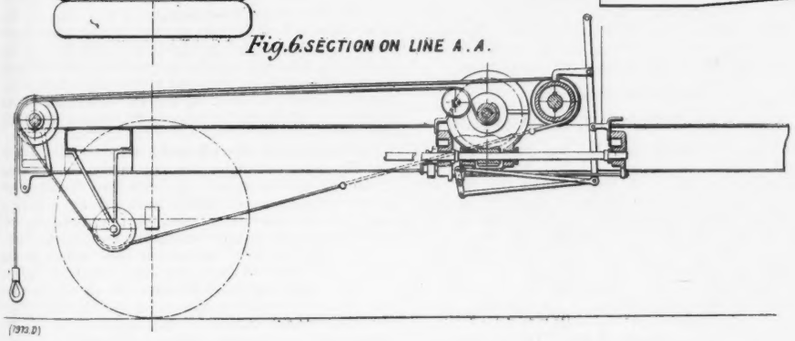


Fig. 6. SECTION ON LINE A. A.



(7973 D)

Fig. 10.

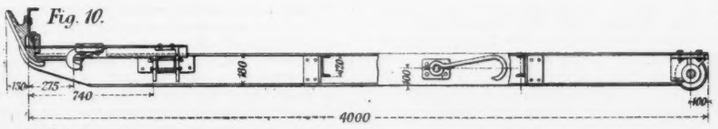
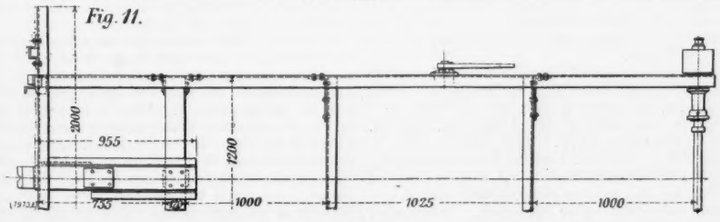


Fig. 11.



(7973 A)

back on to the lorry. This form may be used for the transportation of heavy blocks of stone or for large cases as well as for the conveyance of refuse or ballast. In the case of the last-mentioned example interchangeable boxes are charged with the material and are constructed with a detachable cover at the top, which is removed for loading, and another at the base which can be operated from the winch to facilitate discharge when the frame is in the tipping position. The third form is one specially adapted for the loading and unloading of casks. In this case an L-shaped platform is hinged to the rear of the chassis frame, so that the tail board can be turned back on to the ground. It is the same width as the lorry, and the barrels or casks can be rolled into position on it. When the frame is raised by the winch the barrels are rolled along the lorry platform and the frame is again lowered to raise others. The winch is also available to haul up barrels from cellars when that duty is necessary. The three types of construction have all been tested out in actual working by various motor transport users in Switzerland for over a year, and their installation is said to have been productive of considerable economies.

THE BRITISH EMPIRE EXHIBITION, 1924.—We are informed that the Board of this exhibition proposes to do away with awards altogether and to issue a commemorative medal to each exhibitor. The general feeling, the Board adds, seems to be that having regard to the purely British character of the exhibition and the absence of any element of international competition, it would be in the best interests of the Imperial objects of the exhibition to follow this course. An endeavour is now being made to secure the support of the Dominion and Colonial representatives, and of the United Kingdom exhibitors for such a decision. In the circumstances, the plan appears to us to be a commendable one. It would do away with all jealousies and complaints; there would be no reason for any exhibitor to place upon his stand a placard with the words "Forgotten by the Jury," as was done in at least one instance in the case of one of the Paris International Exhibitions.

USE OF INCOMBUSTIBLE DUSTS IN COAL MINES.—Lieutenant-Colonel G. R. Lane-Fox, M.P., Secretary of Mines, announces that a memorandum has been prepared for the Safety in Mines Research Board to place on record the information that is at present available regarding the application of incombustible dusts in coal mines as a precaution against coal dust explosions. In it have been collated the more important facts and expressions of opinion that have been published since the use of incombustible dusts became general. The memorandum, entitled "The Application of Stone Dust in Coal Mines," may be purchased, price 1*s.* (by post 1*s.* 1*d.*), from any bookseller, or directly from H.M. Stationery Offices.

MOTOR FUELS.—Experiments in the operation of internal-combustion engines with motor benzol, conducted by the United States Department of the Interior at the experiment station of the Bureau of Mines, Pittsburgh, indicate that this type of fuel may serve as a satisfactory gasoline substitute when refined by the use of sulphuric acid or silica gel. The same tests developed the fact that crude motor benzol can only be used satisfactorily after the removal of certain compounds which form gummy deposits and eventually stop the engine. No engine trouble whatever developed when acid-refined or silica gel refined motor benzol fuel was used. It is estimated that 6,202,235,000 gallons of gasoline were produced during the year 1922. The crude light oil output during the same year is estimated at 111,000,000 gallons, or 1·8 per cent. of the gasoline production. If all the coal mined were coked in by-product ovens, and the light oil recovered therefrom, this product would amount to only 15 per cent. to 20 per cent. of the quantity of the petroleum gasoline now produced annually. It is obvious therefore, that the light oils by present coking processes cannot assume great importance as a gasoline substitute in a national sense, but the certainty of a diminution of petroleum resources in the relatively near future demands the utmost utilisation of gasoline substitutes from the distillation of coal as well as from other sources. The Bureau of Mines considers that the engine tests made on motor benzol warrant constructive discussion regarding the present specifications which manufacturers of motor-benzol fuels endeavour to meet. Greater emphasis should be placed on the amount of evaporation residue, rather than on certain other items of present-day specifications such as color. It appears also that the initial boiling-point might be lowered slightly below 78 deg. C.

THE DIESEL-ELECTRIC SHIP "LA PLAYA."

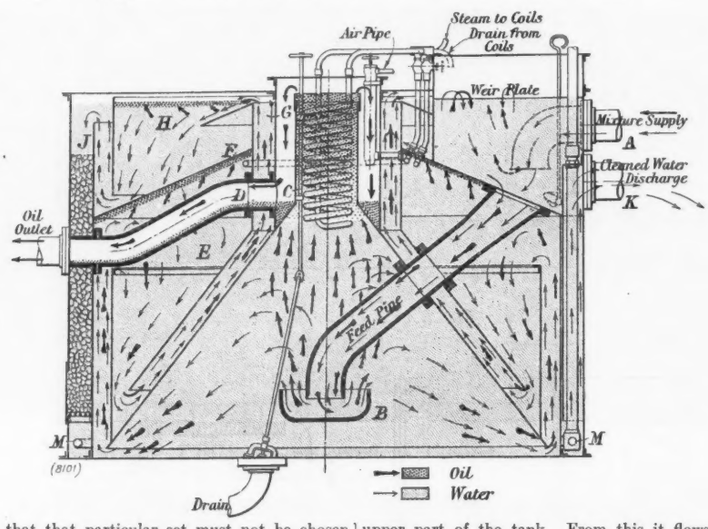
Following on the success of the turbine-electric ship San Benito, of which an illustrated description appeared in our issue of June 16, last year, the United Fruit Company of Boston, Mass., U.S.A., decided further to increase their electrically driven fleet and placed an order for three Diesel-electric ships with Messrs. Cammell, Laird and Co., Limited, of Birkenhead. The first of these ships, La Playa, is now completed and has recently undergone very successful trials. The engineering profession in this country owes a debt to the United Fruit Company for the opportunity which their enterprise has given for further practical study of the electric ship-propulsion question. The La Playa will be employed on the carriage of bananas from the West Indies to North American ports and the division of the propelling machinery into four units, which the Diesel-electric principle has made possible, will enable the units to run at something like full load both when she is making her way north fully loaded and with her refrigerating machinery in operation and when she is returning light. In addition to the advantages in fuel saving which the sub-division of the main units will lead to, the system adopted has resulted in very remarkable saving in machinery space. The increased bin capacity, available for the carriage of fruit, of the vessel over a similar vessel fitted with reciprocating steam machinery is 26·3 per cent. and over the same vessel fitted with turbo-electric machinery is 29 per cent. At full power the fuel oil consumption per 24 hours for vessels of this latter class would be from 31 to 32 tons, while in the case of the La Playa it is 13½ tons.

The boat is fitted with four 4-cylinder Camellaird-Fullagar engines capable of developing 825 b.h.p. at 250 r.p.m. Each engine is coupled to a 500 kw., 220 volt direct current generator, arranged in tandem with, and directly coupled to, which is a 200 kw., 220 volt auxiliary generator. The main generators are connected in series, and at full power, when all the sets are running, the combined voltage of 880 is applied to propelling motors. At lower powers, as one, two or more of the generating units are cut-out, the voltage is reduced to 660, 440 or 220. The auxiliary generators supply the excitation for the main generators and the propelling motors, and also supply current for the ship's auxiliaries and the large refrigeration plant. The propelling motor, is rated at 2,500 b.h.p. at 95 r.p.m., and consists of two units each complete with a separate magnet frame, armature and commutator. The two armatures are electrically connected in series and are mounted on a common shaft supported between two pedestal bearings. As the arrangement consists virtually of two motors in series, it is possible to develop power for about ¾ speed with only one-half of the motor available should a breakdown occur to the other half. Starting, stopping and reversing of the propeller are effected entirely by varying the excitation of the main generators or generator, as the case may be. The main propelling circuits are never interrupted, and all regulation is carried out by varying the field circuits only. Provision is, however, made for isolating any of the generating units as may be desired.

Control is carried out by means of a lever attached to a small controller fixed on the front of a sheet steel panel carrying the necessary control instruments. This lever moves in a fore and aft direction on either side of a central stop point, and all that the operator is required to do when manœuvring is to move the lever on to the speed point required either ahead or astern. The actual varying of the propelling generator field during manœuvring is effected by a reversing potentiometer rheostat in each generator field, all the rheostats being simultaneously operated by a small electric motor. Movement of the control lever switches this motor into circuit, and by means of a follow-up gear the motor switches itself out and stops when it has moved the rheostats to a position corresponding to that to which the lever has been moved. A special type of overload relay is incorporated in the main circuit, and is arranged so that should the operator attempt to accelerate or decelerate too quickly and so cause an excessive power current to flow in the system, the relay interrupts the supply to the small rheostat motor, so that although the lever may be operated quickly the varying of the generator field is only carried out when the current has fallen to such a level that the relay is able to restore the current supply to the small motor. The arrangement allows the operator to carry out orders as quickly as he likes, but at the same time guards the equipment against damage. The board which carries this control gear is fitted with handwheels for independently adjusting the generator fields. It also carries various indicating wattmeters, a speed meter and a series of coloured lamps which indicate which generators are in the main circuit and which set is supplying the exciting current. This latter provision is necessary because the whole of the exciting current may be taken from any set, and in that condition it is obvious that that particular set must not be chosen to be taken off load, until the exciting connection has been transferred to another machine.

The ship contains an unusually large electrically driven auxiliary installation, and there are in all some 39 motors ranging from 1 to 100 h.p. They were manufactured by the Sunderland Forge and Engineering Company. The plant includes nine electric winches supplied by this firm and an electro-hydraulic steering gear by Messrs. Hastie. The CO_2 refrigerating machines by Messrs. Hall are also electrically driven. The vessel is 325 ft. long by 48 ft. in breadth, and 31 ft. 9 in. deep to the upper deck. She has a speed of 14 knots.

THE "ROCKET" OIL SEPARATOR.



The great development that has taken place in recent years in the use of oil fuel for marine propulsion has led to much trouble from the discharge of oily water from the tanks of ships in harbour. As the fuel oil is consumed at sea, the tanks are filled with water to preserve the stability and trim of the ship, and it is mainly from the discharge of this water in port preparatory to the operation of re-fuelling, that the trouble arises. Objections raised to the presence of the oil which collects in considerable quantities on the foreshore in the neighbourhood of large ports led to the passage of the "Oil in Navigable Waters Act," which became operative on January 1 of this year. By this Act, ship masters discharging oily water within certain prescribed limits are liable to heavy penalties, and a ship in harbour must therefore either discharge the water into a barge alongside or through a pipe line to the shore, or else proceed to sea for the purpose. In any case a considerable quantity of oil is lost to the shipowner, and even if it is discharged at sea outside the prescribed limits, much of it drifts back by the action of the wind and tide, creating a nuisance as before.

To recover the oil, and at the same time to avoid the troubles which would arise from the discharge of oily water in port, a device known as the "Rocket" oil separator has been designed by Mr. H. M. Alexander, Assoc.M.Inst.C.E. This device, which is being handled by Messrs. General Oil Conservancy, Limited, 36, St. James's-street, S.W.1, can be installed on the ship for the purpose of recovering the oil and discharging only clear water overboard. It can also, of course, be installed on shore by harbour authorities and others, for treating the oily discharge from ships in port, but the advantage of installing it on the ship is that it can if necessary be used at sea (where at present no restrictions are placed upon the nature of the effluent) for the recovery of oil which would otherwise be wasted. The plant is claimed to occupy but little space, to be automatic in action, requiring very little attention, while it contains no moving parts.

The principle of the apparatus is illustrated in the engraving above, which shows the separator in section. As will be seen, it consists of a cylindrical tank containing a number of conical and cylindrical baffle plates between which the oil and water flows in the directions indicated by the arrows. The mixed oil and water delivered by the ship's pumps enters through the pipe A on the right of the illustration, passing first into a compartment formed in the upper part of the tank. From this it flows over a weir plate (the object of which is to maintain a constant level and to permit any entrained air to escape) through the inclined feed pipe shown and into a central conical chamber B. In this chamber, the velocity of the mixture is reduced sufficiently to allow the greater part of the oil to rise into the cylinder formed on the apex of the cone. This cylinder contains a steam coil which heats the oil and water to facilitate separation and to reduce the viscosity of the oil. As the latter collects here, it flows over the upper edge of the cylinder, which is slightly higher than the level of the weir plate, into the annular space C and out through the pipe D, which is connected to the ship's fuel tanks. More than 90 per cent. of the oil contained in the mixture supplied to the separator is removed in this way.

The water, with the oil which still remains mixed with it, passes out under the bottom edge of the cone B, up through an annular passage into the chamber E, the upper part of which is closed by a conical plate F. On the latter most of the remaining oil collects and travels up towards the apex of the cone where it is heated by the steam pipe shown in the engraving. This oil flows into the outlet through a horizontal pipe controlled by the valve shown, and the same fitting provides a means for the escape of any air which may collect in the upper part of the chamber E.

Water from the latter first passes downwards and then travels up through the passage G, formed by a conical plate mounted coaxially with that forming the chamber B. From the passage G, the water, still containing a small quantity of oil, overflows into the space H at the top of the tank. Any oil which collects on the surface of the water in this space flows over a weir plate at the inlet side and passes again through the body of the separator.

So far, the whole of the separation has been effected by flotation, but the final traces of oil which still remain in suspension in the water when it leaves the compartment H are removed by a process of filtration in the scrubber J. This is formed of clinkers in an annular space which extends round nearly the whole of the body of the separator. The water from the compartment H passes in a downward direction through the scrubber, as indicated by the arrows in the engraving, and the purified water flows upwards through a passage on the right of the illustration, finally leaving through the outlet K and being led overboard.

The oil collected on the clinker in the scrubber is removed at intervals by blowing with compressed air, which is admitted through the perforated pipe M fitted below the scrubber as shown. During this operation, a certain amount of oil may escape with the effluent and if it is necessary to prevent this from being discharged overboard, the effluent can be temporarily by-passed to the ship's tank to be again circulated through the separator after the scrubber has been cleaned. It would, of course, be possible to remove the scrubber from the main separator and to employ the former, as an additional unit, only when a particularly clear effluent is required. The quantity of oil recovered in the scrubber is quite negligible from the point of view of fuel economy.

These separators can be made in various sizes to

deal with from 5 to 200 tons of oily water per hour, but although the internal arrangements naturally differ somewhat in the various sizes, the general principles involved in the design are the same in all cases. On Tuesday last, by the courtesy of Messrs. General Oil Conservancy, Limited, we had an opportunity of inspecting one of these plants installed for demonstration purposes at the Clover-Clayton Dry Docks of Messrs. H. and C. Grayson, Limited, at Birkenhead. The rated capacity of this plant is 100 tons per hour, and the tank used is 10 ft. in diameter by 7 ft. 3 in. in height. It was supplied with sea water mixed with from 12 to 15 per cent. of a very low grade heavy oil, the specific gravity of which, we understand, was 1·003. The discharge was practically clear water, and no free oil could be detected by simple inspection in a test tube. The character of the discharge, however, obviously depends upon the rate at which the plant is worked, and this, we were informed, was at its normal capacity of 100 tons per hour; if circumstances permit a less pure effluent to be discharged, the capacity of the plant could doubtless be greatly increased. A burner fired with the recovered oil was shown in operation.

In addition to the use of the separator for purifying the oily discharge from ships, the proprietors of the patents suggest that the apparatus could be employed in oil fields for separating any water which may be present in the oil as it comes from the wells. It must be pointed out, however, that the plant is only suitable for separating mechanical admixtures of oil and water; emulsions, or colloidal solutions, of oil and water could not be dealt with satisfactorily. Doubtless other industrial uses will be found for separators of similar design to that described, but, at the moment, its most important application appears to be that referred to at the opening of this article.

INDUSTRIAL NOTES.

In the report dated October, issued by the United Society of Boilermakers and Iron and Steel Shipbuilders, we read the following statement by the general secretary: "In the dispute between ourselves and the Federated Shipbuilding Employers we have all along been willing that the Government should decide the issue. We could understand the employers' opposition to such intervention if we had a Labour Government, but as we have a Government overwhelmingly composed of the employing and financial interests it is difficult to understand the employers' opposition to this course . . ." On the face of it, this statement suggests that the present Government is biassed against manual labour, and that a Labour Government, if it were in power, would similarly be biassed against members of the community other than manual workers. The reply to the claim contained in the statement was made months ago; we referred to it in a former issue, on page 111 *ante* where we reported that the employers objected to preferential treatment being given to the boilermakers over other unions working the overtime and night-shift agreement, and that they were not willing therefore to agree to arbitration; hence, the Minister of Labour was unable to accede to the society's request for referring the matter to arbitration, or for setting up a court of inquiry under the Industrial Courts Act. The general secretary does not refer to the action taken by the Federation of Engineering and Shipbuilding Trade Unions, a Federation which expelled the Boilermakers' Society and also, we believe, rejected the proposal of an inquiry. But, as might have been expected, he brings in the political argument and adds "no one can deny that the industry at present is in a very bad state, this being principally due to the mistaken policy of this country towards Germany and Russia . . ." a convenient argument in the circumstances but one in which we are unable to follow him. It is announced that a delegate conference of the Boilermakers' Society is to be held at York to further discuss the matter.

Messrs. R. and J. Garroway, chemical manufacturers, Glasgow, have written a letter to several daily journals, pointing out the action recently taken by a local organiser of the National Union of General Workers—of which Mr. J. R. Clynes is general president—to cause dissatisfaction among their men. Violence was threatened to the men's wives and children at home. As a result of the organiser's action many of Messrs. Garroway's former workers, good and respectable men, are now unemployed. Messrs. Garroway establish a parallel between these facts and a statement made in a speech delivered by Mr. Clynes in the commencement of the present month, at the twelfth annual conference of the British Commercial Gas Association, Birmingham. The statement is to the effect that "perhaps the biggest blunder which most employers committed had been the blunder of seldom yielding that which they could afford to give, except under the pressure of the workers' power to compel. That taught the working classes to appeal to force when deprived of their due." Messrs. Garroway ask who is to decide "what employers could afford to give," and "when men are deprived of their due"; they lay emphasis on Mr. Clynes' assertion that the "appeal to force" comes from the men.

The Central Wages Board for the railway industry met in London last week to consider the proposals made by the railway companies for a revision of the national wage agreement. The trade unions refused the proposals made by the companies for the revision, and the companies, for their part, refused the counter-proposals made by the representatives of the unions. No agreement being reached, the companies' proposals are to be referred to the National Wages Board. These proposals include an alteration in the matter of Sunday duty, the abolition of the special payment for night duty—work done between 10 p.m. and 4 a.m.—the withdrawal of the remaining war bonus when the cost of living index figure reaches 70 points above the pre-war level, a re-arrangement of the pay to drivers and firemen. It is announced that the National Union of Railwaymen is to hold a series of meetings to advocate resistance to the companies' proposals.

A statement issued a few days ago by the Unemployment Grants Committee is to the effect that the Government have in hand a scheme for providing employment during the coming winter. Under this scheme it has been decided to give financial assistance, in respect to revenue-producing works similar to those undertaken by local authorities, to companies who are prepared to commence shortly such works which, otherwise, would not be undertaken by them at the present time. The works referred to cover canals, docks, electricity, gas, harbours, tramways and water. All applications are to be addressed to the Secretary, Unemployment Grants Committee, 23, Buckingham Gate, S.W. 1. Sir William Joynson Hicks, Minister of Health, speaking at Hounslow, last Monday, stated that in conjunction with the Ministry of Transport, Government had authorised a great forward movement in regard to road and bridge construction. We are dealing with these and other points on another page of the present issue.

A Scottish and a Newcastle branch of the Amalgamated Society of Woodworkers have called the attention of the members to the large expenditure incurred by the society under the heading "Trade Management Expenses," by the various Management Committees. They state that they view with alarm the large administration expenses entailed by these committees. The item for room rent is also stated to be greatly in excess of the corresponding expenditure for branch meetings. They request the Executive Council to go closely into these items of expenditure with a view to their reduction. They also think that the time has arrived for withdrawing the national organisers, who are considered to be an expensive luxury; most of their work, it is added, could be done by the district delegates.

The Port of London employers have issued a circular, in which they allege that attempts are being made to compel tugmen to join the Amalgamated Society of River and Waterside Workers, a rival organisation to the Transport and General Workers' Union formed during the recent dock strike. The employers say that steps will be taken to counteract attempts to secure members for the new union by means of threats; any policy of intimidation will be resisted. The master lightermen and tugowners are agreed as to the steps to be taken in the emergency foreshadowed.

It is reported that the workmen in the Royal Dockyards have rejected the Admiralty's scheme to introduce a piecework system, so as to place the dockyards on the same working basis as prevails in private yards. The present rates were to be maintained. The voting was five to one against.

The secretary of the London Iron and Steel Exchange, Limited, reporting upon the meeting of that body which took place on Tuesday last, says that a steady though very gradual expansion in business seems to be taking place in the iron and steel trades, and the conditions at the meeting were more satisfactory than had been the case previously. There was no doubt that whilst the British works were securing a considerable share of the orders coming into the market, they had to cut their prices drastically to do so. In many cases they claimed to be working at a loss, but within the past few weeks their position must have been somewhat eased by the cheapening in prices of raw material. This relief, such as it was, had come none too soon, as there were indications that a revival in Continental competition in an intensified form might be at hand. So far as export business was concerned, the British Colonies and the Far East continued to be the principal buyers.

EXTENSIONS TO HALIFAX POWER STATION.

THE public supply of electricity in Halifax was commenced in December, 1894, and four years later the power station was distinguished by being the first in Yorkshire to instal steam turbines, the machines in question being constructed by Messrs. C. A. Parsons and Co. to drive continuous current dynamos of 200 kw. capacity. In still another four years a three-phase alternating-current supply was generated, this again being the first of its kind in the county. In spite of the early start with turbines, both slow speed and high speed reciprocating engines were subsequently put down, but recent extensions have, of course, been made with turbines, the latest generating unit of this kind to be installed being a 10,000 kw. turbo-alternator which was formally put into commission yesterday, October 18.

The new machine runs at 3,000 r.p.m. and is capable of a continuous output of 12,500 kw. at 80 per cent. power factor, or 15,625 k.v.a. It generates 6,600 volt, three-phase current at 50 cycles, and is one of the largest machines in the country to develop its power at 3,000 r.p.m. The complete unit was designed and constructed by the British Thomson-Houston Company, Limited, of Rugby, the turbine being of their compound impulse type with one compound velocity stage and eight simple stages. Steam is admitted at a pressure of 160 lbs. per square inch and a temperature of 550 deg. F., and exhausts to a 28-in. vacuum. In connection with the new turbine plant four new cross-drum marine type boilers are being installed by Messrs. Babcock and Wilcox, Limited. The boilers have integral superheaters and are arranged in pairs, with a separate Green economiser for each boiler arranged on top of the latter. The rated capacity of each boiler is 37,000 lbs. of steam per hour. The steam pressure and temperature are certainly low, as compared with modern practice, but if as good operating results can be obtained as are shown by the large Radcliffe station, where similar conditions prevail, the Halifax station will compare favourably with many a plant with much higher pressure and temperature.

The condensing plant for the new turbo-generator has been supplied by Messrs. Worthington-Simpson, Limited, of Newark-on-Trent, who built the condensers for the three B.T.H. turbines previously installed. The condenser body is about 10 ft. diameter by 20 ft. long, and contains 7,300 tubes $\frac{3}{4}$ in. in diameter, representing a cooling surface of 23,000 sq. ft. The condenser will maintain a vacuum equal to 1 lb. absolute pressure when condensing 125,000 lb. of steam per hour. The circulating pump, which has to deliver the circulating water against the head of the 70 ft. cooling towers at the rate of 17,500 gallons per minute, is driven by a 300 b.h.p. motor. Air is extracted from the condenser by a hydraulic vacuum pump of Messrs. Worthington-Simpson's design, consisting of a combination of a centrifugal pump with a hydraulic ejector. In addition to this an "Ejectair" steam air-pump, to be used as a stand-by, has been supplied by Messrs. Hick, Hargreaves and Co., Limited, of Bolton. The two additional cooling towers required for the new turbine, will each cool 220,000 gallons of water per hour from 105 deg. F. to 80 deg. F., with an air temperature of 60 deg. F. and a humidity of 80 per cent. The total height of the towers is 70 ft. above ground level. They were supplied by the Premier Cooler and Engineering Company, Limited, of Shalford, near Guildford, Surrey.

The new extensions have been carried out to the specification and under the supervision of Mr. W. M. Rogerson, the Electrical Engineer to the County Borough of Halifax.

THE UNIVERSITY OF SHEFFIELD.—The University Council, at its meeting on the 12th inst., made the following appointments: Professor F. C. Lea, D.Sc. (London), M.Inst.C.E., to the Chair of Mechanical Engineering, in succession to Emeritus Professor Ripper; Mr. Reginald R. S. Cox, B.A. (Christ's College, Cambridge), to the post of Assistant Lecturer and Tutor in Mathematics; Mr. Morgan H. Evans, B.Sc. (Wales), to an Assistant Lectureship in Physics.

MOTOR TAXATION.—A table issued by the Ministry of Transport, dealing with the licences issued from December 1, 1922, to August 31, 1923, and with the approximate tax collected in that period in Great Britain, as returned by the Local authorities, shows that the total gross receipts amounted to 12,662,023*l.* This figure is subject to some adjustment as regards refunds, &c. The rebates allowed in respect of pre-1913 engines in the period amount approximately to 164,000*l.* The total amount of vehicles, excluding tramcars and trade licences in respect of which licences were current on August 31, may be taken as 1,105,000, including 384,000 cars taxed on horse-power, 430,000 cycles, 173,000 commercial goods vehicles and 86,000 hackneys. The average receipt in respect of a whole year licence was 16*l.* 18*s.* 6*d.* for cars taxed on horse-power, 2*l.* 11*s.* 6*d.* for cycles, 21*l.* 7*s.* for commercial goods vehicles and 25*l.* 11*s.* 6*d.* for motor hackneys.

CONDENSING PLANT FOR 20,000-KW. TURBINE AT SHANGHAI.

In Figs. 1 to 9 annexed, and on page 498, we illustrate the surface condensing plant supplied by Messrs. Hick, Hargreaves and Co., Limited, of Soho Iron Works, Bolton, for use in connection with the 20,000-kw. Parsons steam turbine which is now being erected at the Shanghai Municipal Electricity Works. The turbine was fully described and illustrated in our issue of July 13 last. The surface condensing plant is of the Hick-Breguet type, and is designed to condense 239,000 lb. of exhaust steam per hour and maintain a vacuum of 28 in. at the exhaust inlet to the condenser, with a barometric pressure of 30 in., and when supplied with circulating water at 80 deg. F. The amount of circulating water required is 2,400,000 gallons per hour, the cooling surface being 40,000 sq. ft.

As the condensing water, which will be taken from the river, contains a considerable amount of fine mud in suspension, special attention has been given to the avoidance, as far as possible, of reduction in vacuum due to the deposit of such foreign matter on the inside of the tubes. To deal with this aspect of the conditions of working, the condenser has been provided with end box doors in halves. These are carried on a patented system of hinges which allows either of the doors to be opened while the other is closed, so that one-half of the tubes may be cleaned while the other half remains in service. The doors which may also be both opened at the same time if desired, can be seen in the arrangement drawings of the plant, which are reproduced in Figs. 1 and 2, but are perhaps better shown in the general views given in Figs. 7 to 9. With this arrangement for the laying off of half the condenser while the other half is in operation the circulating water connections have to be provided in duplicate, and the arrangements of the two sets of inlet and outlet connections will be seen in the figures. As will be clear from the positions of these connections, the water has two passes through the condenser.

The main shell of the condenser is 11 ft. 9 in. inside diameter and 21 ft. long between tube plates. It is of cast-iron in four parts, and is made of circular form as far as possible, any flat portion being substantially ribbed. The exhaust steam inlet is of rectangular form, 9 ft. wide by 10 ft. long, thus giving an area of entry of 90 sq. ft. The bolting of the various parts is on liberal lines, and is suitable for a test pressure of 15 lb. per square inch. The water boxes are of ample capacity so as to avoid loss of head as much as possible, and maintain a uniform flow of water through all the tubes. The end doors, in addition to being hinged in the way already described, are provided with a number of small hinged inspection doors as will be clear from Figs. 1 and 8. These facilitate inspection of every portion of the tube plates. A further point which may be mentioned, is the provision of numerous bosses on the covers and condenser shell to allow of arrangements for taking pressure and temperature readings, so that the performance of the condenser may be exactly determined under any condition of working.

The tube plates, which are of rolled naval brass, are 12 ft. 5¾ in. in diameter by 1¼ in. thick. They are drilled and tapped to take 14,212 screwed brass ferrules, the number of 1-in. tubes, which are of 60/40 mixture, being 7,106. The tube plates are stayed by a number of longitudinal steel stays extending from one tube plate to the other, the ends of the stays being reduced to pass through the tube plates and provided with manganese bronze cap nuts. Three intermediate galvanised steel plates, ⅜ in. thick, are provided to assist in supporting the tubes. The total weight of the complete condenser, including the tubes, is 125 tons, and this weight in addition to the weight of the water in the end boxes and tubes is carried by spring supports which are clearly shown in Figs. 1 and 7. One of the supports is shown independently in Fig. 3. The total weight carried on the springs is about 165 tons. There are eight supporting feet in all, each fitted with three springs. The supports are provided with heavy setting-up screws which enable the condenser when filled with water in the end boxes and tubes to be lifted evenly, notwithstanding the unequal distribution of load on the supports, in such a way that the exhaust branch of the condenser is lifted up perfectly parallel with the exhaust branch of the turbine, thus removing any unequal loading on the joint. The spring supports are also provided with special compression screws which enable them to be easily withdrawn from under the condenser when required.

The air and other incondensible gases are withdrawn from the condenser by a Hick-Breguet ejectair. The air passes through a devapourising chamber formed by isolating a number of tubes in the lower part of the condenser, the number of tubes so isolated being ample to ensure that any vapour passing along with the air is condensed before entering the air suction pipe to the ejectair. The Hick-Breguet ejectair is illustrated in outline in Fig. 4, and the actual appliance, which is installed in duplicate, is shown in Fig. 5. The apparatus comprises a first and second stage single steam jet with an intermediate condenser. Referring to Fig. 4, air is drawn from the condenser at A and is compressed by a steam jet at B, the steam and air mixture being then discharged into the intermediate condenser C, where the air is cooled and the steam condensed by the water jet D. The air is withdrawn and discharged to the atmosphere or the feed heater by the second-stage ejector E. The vacuum in the auxiliary condenser is usually about 4 in. less than that in the main condenser, so that the condensate from the latter may be used for the jet in the auxiliary condenser. Normally the vacuum in the main condenser is 28 in., the condensate temperature being about 96 deg. F. This condensate can consequently be used for condensing a mixture of steam and air under a vacuum of, say, 24 in., and at a temperature of about 130 deg. F.

The water from the auxiliary condenser is drained away by passing it back to the extraction pump suction by means of a balance pipe, which, in addition to draining the auxiliary condenser, also provides the balance of pressure between the latter and the main condenser. The whole of the heat of evaporation of

CONDENSING PLANT FOR 20,000-KW. TURBINE.

CONSTRUCTED BY MESSRS. HICK, HARGREAVES AND CO., LTD., ENGINEERS, BOLTON.

Fig. 1.

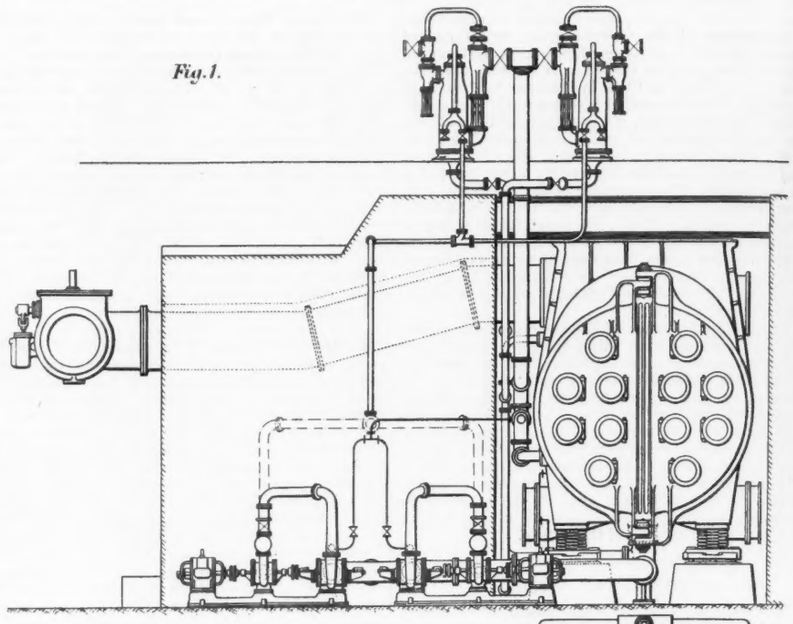
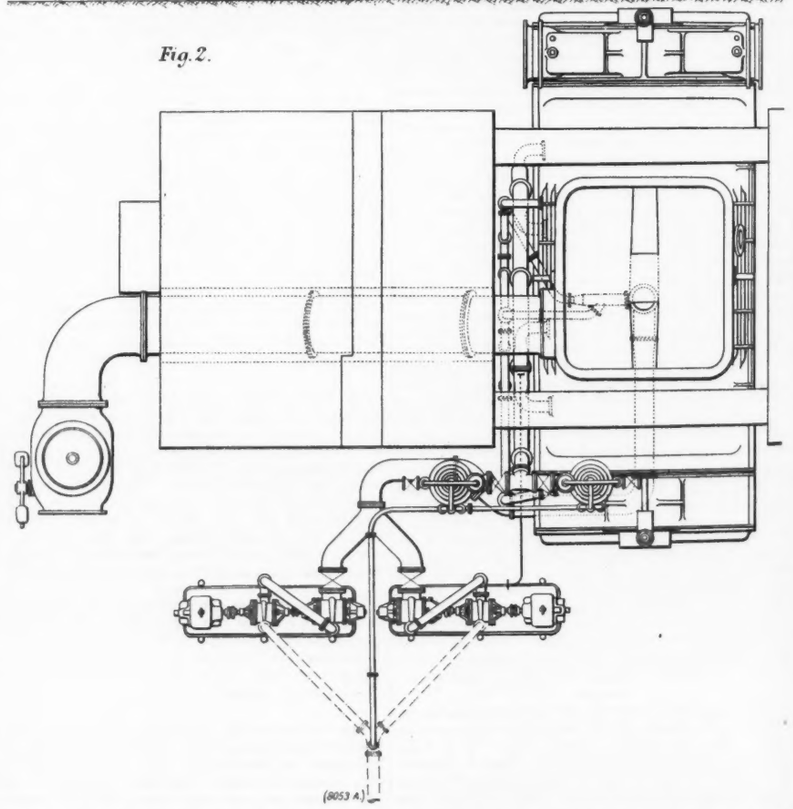


Fig. 2.



CONDENSING PLANT FOR 20,000-KW. TURBINE AT SHANGHAI.

CONSTRUCTED BY MESSRS. HICK, HARGREAVES AND CO., LIMITED, ENGINEERS, BOLTON.

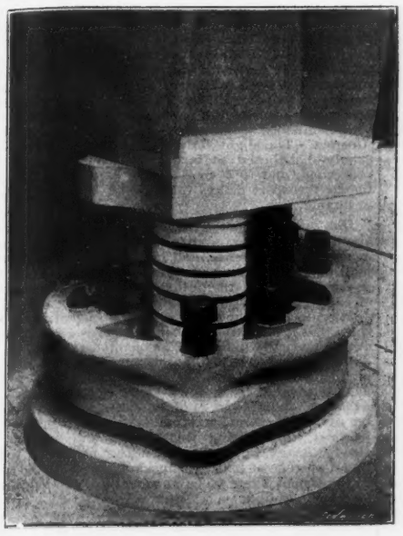


FIG. 3. SPRING SUPPORT.

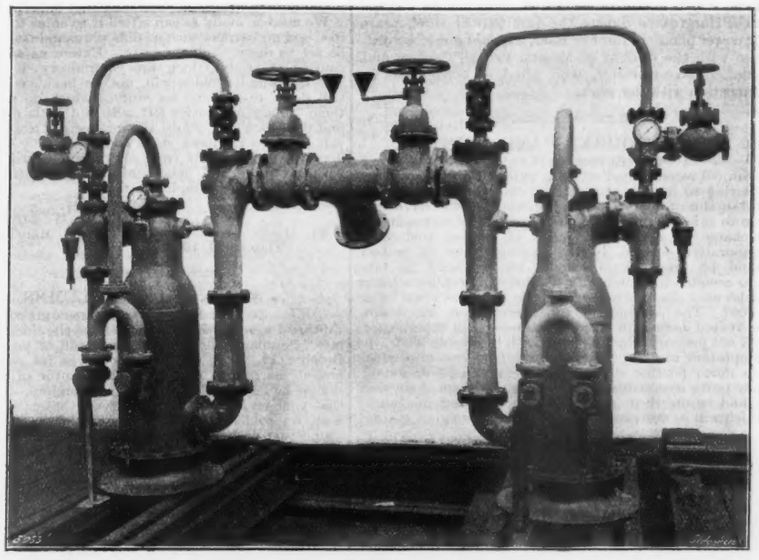
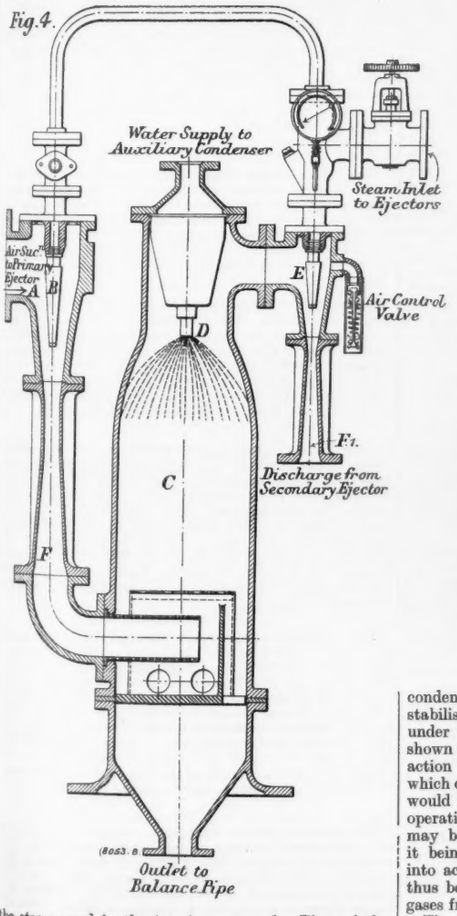


FIG. 5. HICK-BREGUET EJECTAIR.



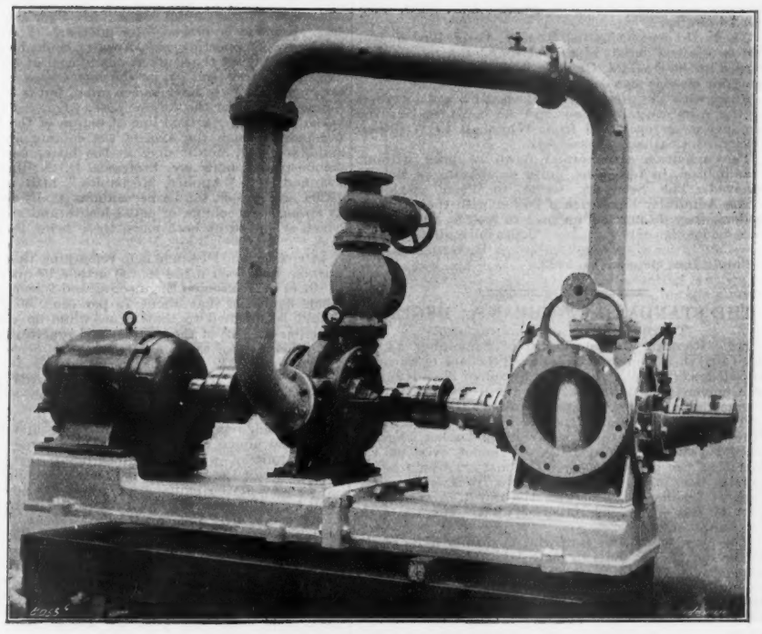


FIG. 6. EXTRACTION AND LIFT PUMPS.

the steam used in the jets is recovered. That of the first jet is added to the condensate withdrawn from the main condenser by passing it through the drain balance pipe from the auxiliary condenser, while the heat from the second jet is absorbed in a feed heater, the condensate from the main condenser providing the condensing medium. The ejectair is fitted with a stabilising air valve which ensures stability of vacuum under all conditions of load. This valve, which is shown in Fig. 4, is adjusted so that it only comes into action when the main unit is on very light load, under which condition the vacuum in the auxiliary condenser C would tend to become too high to ensure satisfactory operation of the second stage ejector E. The apparatus may be in service for very lengthy periods without it being necessary for the stabilising valve to come into action, the whole of the energy in the steam jet thus being utilised for the extraction of air and other gases from the condenser.

The extraction pumps for withdrawing the condensate are of Messrs. Hick, Hargreaves' standard design and manufacture. The casings are of cast-iron and are provided with suction branches of ample area to ensure an easy flow of condensate into the pump. The impellers are of bronze alloy, zinc free, and are carefully balanced to ensure efficiency and freedom from vibration. The spindles are of steel fitted with bronze sleeves, the packings being of the labyrinth type with water connections of liberal size ensuring complete exclusion of atmospheric air from the pump casing under all conditions of working. The arrangement eliminates packings of a fibrous type, and sleeve erosion due to their use. The spindles are carried on bearings of the ring-oiling type. In addition to the extraction pump, a lift pump is provided to enable the condensate to be pumped against the relatively high discharge head amounting to about 73 ft. This latter pump calls for no detailed comment, being of the standard centrifugal type fitted with renewable sleeves on the spindle, which is carried in ring-oiled bearings, similar to the extraction pump bearings. The two pumps are carried on one bed plate and driven by the same motor as shown in Fig. 6. As shown in Figs. 1 and 2, the sets are duplicated, as in the case of the

ejectairs, so that a reserve is available against a risk of shut-down of the plant due to the breakdown of an auxiliary unit. The plant is further provided with an automatic atmospheric exhaust valve 36 in. in diameter, which prevents damage to the condenser should the machine for any reason go over to atmosphere. The plant, which is one of several constructed by Messrs. Hick, Hargreaves during the last two or three years for power plants in the Far East, was laid out in accordance with the designs of Messrs. Preece, Cardew and Rider, of Westminster, who acted as consultants in connection with the work.

STEAM TURBINES AND PRIMING.

To the Editor of Engineering.

Sir,—I recently had occasion to look through statistics referring to failures of turbines in electric light stations, and in almost every case the trouble seems to have been due to priming; so it might prove helpful to engineers in-charge if a table of ratios of heating surface to evaporative surface, in the various types of boilers, could be prepared. It would be necessary to take into account the conditions of working, because a boiler under easy steam is not so likely to prime as when being forced. The addition of superheaters has, no doubt, prevented damage in several instances. But superheaters will not prevent priming; and, with increasing loads, the temptation to raise the efficiency of boilers, into which too much heating surface has already been crammed, may prove irresistible in some cases. Makers of turbines should be on their guard against suppying machinery which will be destroyed if it gets water instead of steam.

Yours obediently,

"Investigator,"

October 16, 1923.

"INVENTION AND PRACTICE."

To the Editor of Engineering.

Sir,—The reference of October 5, page 433, "Invention and Practice," to Francis Ronald and his electric telegraph, 1816, reminds me of the history related by Mr. W. H. Barlow, the civil engineer, of a similar experience of his father, Peter Barlow, Professor at the Royal Military Academy, Woolwich, of the same date, with the Admiralty.

About the same time as Ronald, Peter Barlow had run an electric circuit of thread round the trees of his garden at the Orchard, Old Charlton, and found he could transmit electric signals in a telegraphic message.

Fired with the discovery he dashed off a description to the Admiralty, to show how he could replace the semaphores in operation from Whitehall to Woolwich Dockyard, Chatham, Portsmouth.

The invention was turned down at once without examination, in terms not quite so delicate as Ronald received. The Secretary wrote to Peter Barlow—"The Admiralty have such a bother with their present system, they do not feel inclined to look at any other."

Yours faithfully,

G. Greenhill.

Staple Inn, October 13, 1923.

THE STANDARD OF THE B.Sc. DEGREE."

To the Editor of Engineering.

Sir,—Recently (in your issue of September 28, on page 402) there appeared remarks on the lack of scientific knowledge of some of those who have had the advantage of a university training and who are in possession of an engineering degree. As a graduate I read these remarks and subsequent correspondence with considerable interest. However, I am not yet in sackcloth and ashes over my wasted years at a university. I cannot overlook the fact that the greater part of the matter, which is not purely descriptive, in Engineering itself is from the pens of graduates; also that the direction of a great part of the engineering progress of the country is in the hands of graduates.

The member of your staff who so readily hurls bricks at the universities, fails to realise the true function of a university training. It is not just a means of acquiring so much book knowledge. The captain of the college football team or the secretary of the debating society with an "imperfect acquaintanceship of fundamental principles of mechanics and thermodynamics" will probably be a better engineer than the unfortunate young man who has ruined his health by trying to get a perfect (!) knowledge of such things, and who has neglected the more essential study of his fellow men. In engineering, a knowledge of the behaviour of men is of as much importance as a knowledge of the behaviour of materials.

The object of the university degree course should be to whet a man's appetite for knowledge, since the obtaining of a degree is but the beginning and not the end of the development of a trained mind. The standard for a degree may be a low one: it is right that it should be so. No more can be attempted than to put a student on the track of how and where to find the knowledge which, amongst all accumulated knowledge, will be of most value to him. The university training should leave the student in the best of physical and mental health, equipped with good manners and address, and sufficient knowledge of his fellow men to be able to work tactfully with them and to see his own work in its proper relation to the rest of life.

As I write there comes to my mind the name of one of our most distinguished engineers, who owed his degree more to the kindness of his professors than to any ability to pass examinations. Would it have served an useful purpose to have debarred him from the hall-mark of the university he left carrying its "Intangible Exports" (to quote the title of your leading article)? His vigorous personality, which has given much useful service to mankind would have been greatly handicapped had the university marked, him down as a failure because his knowledge of the "fundamental principles of mechanics and thermodynamics" was imperfect.

We need as many as can afford it to enter the universities, and no barriers such as difficult examinations should be set to drive students away. Extensive and difficult courses of study which are compulsory do no good. The Osborne-Reynolds will not be benefited by being tied down to arduous set studies which do not attract them. They are better left with but little guidance to find their own way, whilst the intellects of lesser capacity will only be rendered stale and lifeless by overstudy. Some of the students from our technological institutes with extensive and dehumanising examination courses are outstanding examples of this.

Yours truly,

C. W. Loveridge.

29, Mayfield-road, Whalley Range, Manchester,
October 9, 1923.

STRENGTH OF COLUMNS.

To the Editor of Engineering.

Sir,—I agree with your reviewer of the third edition of my "Popular Fallacies," at page 459 of your issue of October 12, 1923, that "who drives fat *oxen* should himself be fat"; *a fortiori*, the mentor of the driver should be "fatter" still! It is, therefore, unfortunate that your reviewer has not exercised that care in dealing with a problem in engineering which is expected in connection with one of the leading engineering papers, especially as that lack of caution may damage the reputations of your paper, Professor D. A. Low, Wh.Sc., M.I.Mech.E. (to whose "Applied Mechanics" I referred), and myself unless the matter is suitably put right. Had the exact words been quoted from page 882 of "Popular Fallacies," viz. (that it is a fallacy) that a column free at one end and fixed at the other is stronger than one which is rounded or hinged at both ends, then your more observant readers would have been able to realise what the problem is and where the reviewer went wrong, but unfortunately in each case the all-important words "free at one end" are omitted, and it has not been noticed that I was careful to use "free" for one condition and "rounded or hinged" for another. A column *free* at the top (supporting, say, a water tank) and fixed at the bottom is *not* the same as one hinged at the top and fixed at the bottom. It is the latter case which your reviewer appears to have had in mind, but is not the one I dealt with. In the former case, when deflection has taken place, the vertical line of action of the load does not pass through the axis of the column at its lower and fixed end, but it does in the latter case, and as demonstrated both by Professor D. A. Low (pages 165 and 166 "Applied Mechanics," fifth impression, 1920), and myself, the former column is only one-quarter as strong as a column of equal length and cross-section which is hinged at both ends, these being in a vertical line.

In conclusion, I cannot help remarking that even if a mistake had been made in the article in question (one of 191 in the section on Engineering and Science) it hardly seems equitable that about 75 per cent. of the review should be devoted to that error, while no comment is made on the rest of the section, and practically none on any other part of the book.

Yours very truly,

A. S. E. Ackermann.

17, Victoria-street, Westminster, London, S.W. 1,
October 15, 1923.

[We much regret that, owing to a misunderstanding, the review above referred to included some comments to the tone of which Mr. Ackermann justly objects. The author of the review now writes us as follows:—

"In view of the explanation which he now gives of what he really meant, I much regret the terms in which I criticised Mr. Ackermann's statement. What he said was that there was a popular fallacy to the effect that 'A column free at one end and fixed at the other was stronger than a column rounded or hinged at both ends.' Mr. Ackermann's statement, as it stands, implies that a kitchen table would be strengthened fourfold by hinging the legs at the top. It appears, however, that what Mr. Ackermann meant was that a column guided at both ends but otherwise free is stronger than one which is fixed at the base and free from all guidance at the top. This, however, cuts across no popular belief, since it is, I think, generally recognised that a pole resting on the ground and stayed by guys at the top can carry a heavier load than if merely fixed like a lamp post. It was this claim to dispose of a popular fallacy that occasioned the misconstruing of the author's meaning. On this interpretation the relative strengths were, of course, as stated, but it has to be borne in mind also that even Mr. Ackermann's amended statement only applies to slender columns and not to columns generally. In view of Mr. Ackermann's explanation of what he really did mean, I much regret the adverse comment, but would add that paradox is out of place in scientific and technical matters, where too much care cannot be expended in avoiding ambiguity."—The Reviewer.]

Finsbury Old Students' Association.—The Twelfth annual dinner will be held at the Engineers' Club on Saturday, November 10, when the chair will be taken by the president, Mr. W. M. Mordey, M.Inst.C.E., M.I.E.E., at 7 p.m. Tickets may be obtained from the Hon. Secretary, H. P. Guy, 74, Silver-street, Edmonton, N. 18.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Hull Coal Traffic.—For the first time this year, the official monthly returns relating to South Yorkshire coal trade *via* Hull show a check for September, the total receipts, 531,555 tons, representing a decline of 35,938 tons as compared with the corresponding month last year. For the nine months including September, however, the total tonnage dealt with increased by 1,462,040 tons compared with 3,785,415 tons for the first nine months of 1922. An outstanding feature on the export side was that Germany took over one-third of the total tonnage of steam hards sent from South Yorkshire during the nine months. Business with France accounted for nearly one-sixth of the gross deliveries. Next in order of prominence came Holland, Belgium and South America. The slight shrinkage on the month was fairly evenly distributed so far as individual collieries were concerned, and to a considerable extent was accounted for by transport delays rather than by any diminution in buying.

Iron and Steel.—Judged by the number of inquiries in circulation, business in steel and engineering products is again on the up-grade, and more active conditions may be looked for during the closing months of the year. A quietly optimistic outlook finds a certain measure of support in the official statistics relating to steel production in Sheffield and district for August last. These show that instead of a further relapse, as was anticipated, output actually increased as compared with the preceding month by 18,000 tons, the total being not far short of 100,000 tons. Half of this was of basic steel and 34,000 tons of acid steel. The armament branches, whose general outlook is obscure, are partially employed on orders for armour plate and armour-piercing projectiles. Shipbuilding work is coming forward very slowly, heavy forges and foundries not being engaged on an average at half their normal capacity. Nor is any improvement likely to be in sight until the longstanding shipyard trouble is satisfactorily settled. The construction of railway rolling-stock and railway materials in the form of axles, wheels, tyres and springs continues an outstanding feature of local production. Electrical engineers are busier than was the case two months ago. Many substantial inquiries are in circulation on this account, which should yield a nice volume of business. Electrical materials are required for Italy; tenders are being sought for girder spans for New Zealand; West Australia is in the market for steel pipes, and the British Admiralty is inquiring for cutlery supplies and implements. Hardware and small tools are improving in individual sections, though generally speaking there is exceptionally keen competition for the comparatively small amount of work on offer, and prices are down to the lowest possible limit.

The North-East Coast Institution of Engineers and Shipbuilders.—The fortieth annual general meeting of this Institution is being held to-day, at 7.30 p.m., at the Literary and Philosophical Society, Westgate-road, Newcastle-upon-Tyne, the proceedings including the reading of a paper by Dr. Guy D. Bengough on "The Causes of Rapid Corrosion of Condenser Tubes."

Twin-Screw Stern-Well Bucket Hopper Dredger for Queensland.—The Department of Overseas Trade is informed that the Port of Queensland invites tenders for the construction and delivery of a self-loading hopper bucket dredger of the stern-well type. Tenders close in Brisbane on March 31, 1924. Further particulars are obtainable on application to the Department of Overseas Trade, 35, Old Queen-street, London, S.W. 1.

The Thornycroft Engineering Society.—Messrs. John I. Thornycroft and Co., Limited, Basingstoke, have sent us the programme of the forthcoming meetings of their local engineering society. The meetings commenced on the 3rd inst., when Mr. Tom Thornycroft gave a paper on "The Evolution of the Modern Hydroplane Boat." The next meeting takes place on the 17th inst., on which day Mr. E. P. Willoughby will read a paper on "Valve Timing." Twelve other meetings will be held down to April 2, all dealing with technical subjects.

New Bridge at Tientsin, China.—The Commercial Counsellor at Peking has forwarded to the Department of Overseas Trade copies of the official text of a call for tenders by the Hai Ho Conservancy Commission for the delivery and erection of a bridge over the Hai Ho at Tientsin. Tenders must be in the hands of the Commission before noon on May 1, 1924. The cost of erecting the new bridge has been roughly estimated at Tls. 700,000, about 105,000*l*. Full particulars of the contract are obtainable on application to the Department of Overseas Trade, 35, Old Queen-street, London, S.W. 1.

The Alsace Potash Deposits.—In the latest edition of the French Lambert annual, giving statistical data on chemical products, it is stated that the Alsace potash deposits under German management yielded 350,341 metric tons of crude potash salts in 1913, the yield, still under German management, being a total of 1,891,577 tons for the eight years from 1911 to 1918 inclusive. The yield of the Alsace deposits, under French management, was 464,605 metrical tons in 1919, 1,061,196 tons in 1920, 900,000 tons in 1921, and 1,350,000 tons in 1922, a total for four years of 3,775,801 metric tons. The total German yield of crude potash salts was 11,956,500 metric tons in 1913, and 12,780,700 metric tons in 1922.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is rather more doing in Cleveland pig-iron. Home demand shows some little improvement, and Continental customers are taking a little more interest in this market. Business, however, is still on a very limited scale. There is very little demand for No. 1, but there is next to none available for disposal, and the price is maintained at 102*s.* 6*d.* No. 3 has shown some movement since our last report. A sharp drop found some sellers accepting as low as 94*s.*, but there was a quick recovery, and the market quotation is once more 96*s.*, with some makers asking more. Foundry 4 is on sale at 91*s.*, and No. 4 forge is put at 88*s.*, but little of these qualities is offered in the open market. All the foregoing quotations are f.o.t. makers' works, and f.o.b. Tees.

Hematite.—Output of East Coast hematite is insufficient for current needs with the result that makers' stocks are being substantially drawn upon to meet demand, and the position of producers is being much strengthened. Home requirements are expanding, and buying on Continental account continues on quite a good scale. Under such conditions values show further rather marked upward tendency. The minimum home and export quotation for Nos. 1, 2 and 3 is 99*s.*, and some makers are holding out for nearer 100*s.* No. 1 finds a ready market at the latter figure.

Foreign Ore.—Imported ore is still very slow of sale, but unloadings so far this month, in fulfilment of old contracts, are on a heavy scale. Market rates remain on the basis of 23*s.* c.i.f. Tees for best rubio.

Blast-furnace Coke.—There is again scarcity of Durham blast-furnace coke, and prices are stiff. Good medium kinds are in the neighbourhood of 39*s.* delivered at local consumers' works.

Manufactured Iron and Steel.—Some little improvement is noticeable in one or two branches of the finished iron and steel industries. Export inquiries for steel are a little better and have resulted in one or two contracts being arranged, but works are running at nothing like their capacity and orders are keenly sought after. Principal market quotations stand:—Common iron bars, 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.*; steel ship, bridge, and tank plates, 9*l.* 15*s.*; steel angles, joists, and heavy rails, 9*l.* 10*s.*; fish plates, 12*l.* 10*s.*; black sheets, 15*l.*; and galvanised corrugated sheets, 19*l.* 5*s.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Exports of coal from Cardiff, Newport, Port Talbot and Swansea in September, according to the returns of H.M. Customs, amounted to 2,289,659 tons, valued at 3,028,476*l.*, representing an average value of 26*s.* 5*d.* per ton. Compared with August the volume showed a reduction of 36,861 tons and the value of 68,969*l.*, and the yield per ton was 2*d.* lower but still 3*s.* 1*d.* higher than in January. The volume and value of shipments from the different ports in September is shown below:—

From—	Quantity. Tons.	Value. £	Average. Per Ton. s. d.
Cardiff... ...	1,321,356	1,748,035	26 6
Newport ...	446,525	582,430	26 1
Port Talbot ...	243,055	313,586	25 10
Swansea ...	278,723	384,425	27 7
Totals ...	2,289,659	3,028,476	26 6

Exports from Cardiff were reduced by 70,918 tons, but the average value per ton was stationary, and while shipments from Swansea were lower by 16,782 tons the average price was also 1*s.* 2*d.* less. At Newport trade was increased to the extent of 33,583 tons, and the average price was advanced by 4*d.* per ton, but at Port Talbot where shipments were increased by 17,256 tons, the price was lower by 2*d.* Exports of large coal in September totalled 1,510,868 tons, and represented about 66 per cent. of the total, while throughs at 69,271 tons were 3 per cent., and smalls at 709,520 tons were 33 per cent. of the total. Large coal at 29*s.* 5*d.* showed a fall of 3*d.* per ton, throughs at 22*s.* 2*d.*, a reduction of 1*s.* 4*d.*, and small at 20*s.* 11*d.*, a decline of 1*d.* per ton when compared with the August values. Exports of anthracite coal from Swansea totalled 164,956 tons, valued at 261,401*l.*, which represented a reduction of 33,586 tons in volume and of 55,557*l.* in value, notwithstanding that the average price of large per ton at 44*s.* 8*d.* was 1*s.* 2*d.* higher than in August, and that small at 23*s.* 11*d.* showed an increase of 10*d.* per ton. Exports of patent fuel from South Wales in September amounted to 101,234 tons, valued at 162,738*l.*, while shipments of coke totalled 26,104 tons, valued at 57,664*l.* Meanwhile conditions on the coal market show little alteration. Inquiries on contract account over next year are more numerous, but actual business is still held in abeyance owing to the difference in the ideas of buyers and sellers. Buyers are ready to book up business on the basis of last year's prices or round about 25*s.* 6*d.* for best Admiralty large, but salesmen at present will not look at this figure and ask from 1*s.* 6*d.* to 2*s.* more. For current business, operators are adopting a hand-to-mouth policy, and prices are governed by individual circumstances with best Admiralty large round 28*s.*, the leading Monmouthshires from 26*s.* to 27*s.* 6*d.* and drys from 26*s.* to 27*s.* Smalls generally are steadier owing to pit stoppages having curtailed outputs. The best bunkers are round 18*s.*, but the inferior grades are offered at anything from 13*s.* to 16*s.*

Iron and Steel.—Exports of iron and steel goods from South Wales last week totalled 22,000 tons, of which 8,490 tons were tin plates, 7,260 tons black plates, 2,790 tons galvanised sheets and 3,460 tons other iron and steel goods.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The long delay in reaching any settlement in the dispute with the boilermakers has had a very serious effect on the steel trade of Scotland, and recent bookings of almost any description have been extremely poor. Order books are very bare now and a hand-to-mouth existence is all too general at the various works. Inquiries are quite good on the whole, particularly for export, but the competition for these lots is rather keen, and very low prices have to be given, and despite that, the contracts fixed up are not numerous so far. With shipbuilding at such a low ebb the demand for plates and sections is now at the minimum. The black sheet makers continue fairly busy on light-gauge sheets on export account, but there is still little business passing for the heavier gauges. Galvanised sheets are in quite good demand. Prices show no change over the week and are as follows:—Boiler plates, 13*l.* per ton; ship plates, 10*l.* per ton; sections, 9*l.* 15*s.* per ton; and sheets, 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The West of Scotland malleable iron trade has not improved, and with little being booked the works are only partially moving. Home buyers are not entering into engagements beyond actual requirements, and these are very limited on account of the prevailing trade depression. The export side of the industry is also dull, while in the steel re-rolling branches there is not so much activity at the moment, the demand having eased off to some extent. The current price of "Crown" bars is 12*l.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—A quiet tone continues to rule in the Scottish pig-iron trade and stocks are accumulating. Buyers of hematite and foundry sorts are in little evidence just now, and even the easier tendency of prices has failed to bring out any appreciable amount of fresh business. To-day's quotations are as follow:—Hematite, 5*l.* 5*s.* per ton, delivered at the steel works; foundry iron No. 1, 5*l.* 3*s.* 9*d.* per ton, and No. 3, 4*l.* 18*s.* 9*d.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipment of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, October 13, amounted to 1,813 tons. Of that total, 1,694 tons went overseas and 119 tons coastwise. For the corresponding week of last year the figures were 5,615 tons overseas and 52 tons coastwise, making a total shipment of 5,667 tons.

ELECTROTHERMIC ZINC SMELTING.—Conditions being equal, the electrothermic process for the smelting of zinc may be said to have the advantage over the electrolytic process in the items of power, labour, metal recovery, cost of roasting, first cost of plant, and in its adaptability to smaller scale operations, according to B. M. O'Harra, associate metallurgist of the Department of the Interior-United States, who has undertaken a study of the electrothermic metallurgy of zinc under a co-operative agreement between the Bureau of Mines and the Missouri School of Mines and Metallurgy. The electrothermic process is superior to the retort process in the items of reduction fuel, labour, metal recovery, ability to treat low-grade and impure ores, cost of roasting, first cost of plant, and cost of retorts and condensers. The electrothermic smelter, states Mr. O'Harra, must be near cheap power, as must also the electrolytic, but as many retort smelters are now some distance from their supply of ore this is no great difficulty. Each of the three processes—retort, electrolytic, and electrothermic—has its particular field, and there are undoubtedly places in the United States where the electrothermic process could be profitably applied.

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—The arrangements already made for the sixty-seventh session of this Institution indicate that a very successful year's work under the presidentship of Mr. J. Howden Hume may be anticipated. Papers on the syllabus connected with shipbuilding include one on that question of absorbing interest at present, "The Subdivision of Ships." It is to be presented by Mr. J. Foster King. Others concern "The Board of Trade and Merchant Shipping," by Frank R. Blair, and "Efficiency in Ship Construction from the Strength Point of View" which will be read by Dr. J. Bruhn. The results of experimental investigations at the National Physical Laboratory by Messrs. G. S. Baker and G. H. Bottomley will be given in a paper on "The Manœuvring of Ships, Part II.—Unbalanced Rudders of Twin-Screw Ships." Another paper, in which the results of investigations are to be submitted, is on "Tests on a Cylindrical Marine Boiler With and Without Pre-heated Air," which will be read by Mr. W. H. Owen. Questions relating to oil engine propulsion for ships and the auxiliaries for vessels using that system form the subjects of three papers by Messrs. A. E. L. Chorlton, John C. M. MacLagan and Robert Love. Other contributions on "Losses in Turbine Pumps," by Dr. W. Blackadder; "Pipe Bending by Machinery," by Mr. C. R. H. Bonn; "Pumping Machinery in Holland," by Professor J. C. Dijxhoorn; "Monel Metal," by Engineer Rear-Admiral Anstey; and "The Handling of Coal at Rotterdam," by Professor F. Westendorp, complete an admirable list.

NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 19, at 7.30 p.m., at 39, Victoria-street, S.W. 1. Lecturette: "The Gas Boiler (or Circulator) and Its Application," by Mr. F. W. Dye. Friday, October 26, at 7.30 p.m. Lecturette: "Crystals for Wireless Reception," by Mr. A. V. Ballhatchet (Member).

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, October 19, at 6 p.m., at Storey's Gate, St. James' Park, S.W. 1. Presidential Address by Sir John Dewrance, K.B.E. Graduates Section, London, Monday, October 22, at 7 p.m., "Four-Wheeled Brakes for British Light Cars," by Mr. John Harrison, Graduate, of London. Chairman, Mr. L. A. Legros, O.B.E., Member of Council.

THE INSTITUTE OF METALS, SCOTTISH LOCAL SECTION.—Friday, October 19, at 7.30 p.m., at the Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow. Paper on "Large Metallic Crystals and Some of their Properties," by Professor H. C. H Carpenter, F.R.S.

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Friday, October 19, at 6.45 p.m., at the Education Offices, St. James'-road, Dudley. Presidential Address by Mr. F. J. Cook.

THE BRADFORD ENGINEERING SOCIETY.—Monday, October 22, at 7.30 p.m., meeting in the Hall of the Bradford Technical College, a paper will be read by Mr. H. E. Pearsall, A.M.I.M.E., Wolverhampton, on 'Steam Boilers." Illustrated by lantern slides.

THE INSTITUTE OF PHYSICS.—Monday, October 22, at 5.30 p.m., in the Hall of the Institution of Electrical Engineers, Victoria Embankment, W.C. 2. Lectures on "Physics in Industry," No. 5, "The Physicist in the Textile Industries," by Mr. A. S. Oxley, D.Sc.F.Inst.P.

THE NORTHAMPTON ENGINEERING COLLEGE ENGINEERING SOCIETY.—Monday, October 22, at 5.30 p.m., at the Northampton Engineering College, St. John-street, E.C. 1. A paper on "Hydro Electric Installations," by Mr. J. H. Ratcliff. Mr. F. M. Denton in the chair.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS.—Thursday, October 25, at 7 p.m., at the Engineers' Club, Coventry-street, W. 1. Presidential Address, followed by paper by Mr. B. R. Byrne (Assoc. Member), "Fatigue of Iron and Steel."

THE NEWCOMEN SOCIETY.—Friday, October 26, at 5.30 p.m., in Prince Henry's Room, 17, Fleet-street, E.C. 4. Presidential Address by Mr. L. St. L. Pendred, on "The Value of the History of Technology."

THE INSTITUTION OF LOCOMOTIVE ENGINEERS, SCOTTISH CENTRE.—Thursday, October 25, at 7.30 p.m., in the Societies' Room, Royal Technical College, George-street, Glasgow. Paper by Mr. David S. Anderson, B.Sc., A.R.T.C., "The Problem of the Locomotive Condenser"; at 2.30 p.m., visit to the Glasgow Corporation Electric Power Station, Dalmarnock.

FUEL COMBUSTION AND SMOKE REDUCTION.—Messrs. Meldrums, Limited, Timperley, near Manchester, inform us that they are willing to lend a set of lantern slides relating to fuel combustion, smoke reduction, &c., to societies and institutions for illustrating lectures. They are also prepared to supply lectures, or the material for lectures, on these subjects.

THE INSTITUTION OF MECHANICAL ENGINEERS.—THOMAS HAWKSLEY LECTURE, 1923.—Sir Westcott S. Abell, K.B.E., M.Eng., will deliver the above lecture on "The Mechanical Problems of the Safety of Life at Sea," at the Institution, Storey's Gate, Westminster, on Friday, November 2, 1923, at 6 p.m. Visitors are invited. The lecture will be repeated in Liverpool, November 8; Leeds, November 9; and Glasgow, December 7.

UNIVERSITY OF LONDON, UNIVERSITY COLLEGE.—The calendar of University College for the session 1923–24, a volume of over 600 pages, is now available. It enters in detail into the various courses of study offered in a number of faculties. It also gives a brief history of the college, the lists of officers, professors, particulars concerning the college societies, scholarships, and so forth. The book is carefully indexed. It is published by Messrs. Taylor and Francis, Red Lion-court, Fleet-street, London, E.C.

THE IRON AND STEEL INSTITUTE.—The volume CVII, issued by this Institute is now available. It deals with the proceedings of the last spring meeting, the papers read and the discussion thereon covering 583 pages. There are, further, over 160 pages of abstracts from journals published throughout the world, the whole being as usual most carefully indexed. There comes to hand at the same time vol. xii of Carnegie Scholarship Memoirs, a volume of 295 pages, which also contains an interesting contribution by Dr. J. N. Newton Friend, on "Iron in Antiquity."

ENGLISH-SPANISH-PORTUGUESE TECHNICAL DICTIONARY.—A technical dictionary of English technical terms, with both Spanish and Portuguese equivalents, by Mr. Thomas F. Palmer, is published at the price of 7*s.* 6*d.* net by Messrs. E. Marlborough and Co., Limited, 51, Old Bailey, E.C. 4. It is divided into 11 sections dealing with aeroplanes and airships, shipping terms, shops, wood-working machines, &c. It appears to us very complete; geographically, it covers Spain, Portugal and the whole of Central and South America, and should prove a boon to all British traders dealing with these parts of the world and also to large numbers of engineers.

CONDENSING PLANT FOR 20,000-KW. TURBINE AT SHANGHAI.

CONSTRUCTED BY MESSRS. HICK, HARGREAVES AND CO., LIMITED, ENGINEERS, BOLTON.

(*For Description, see Page* 494.)

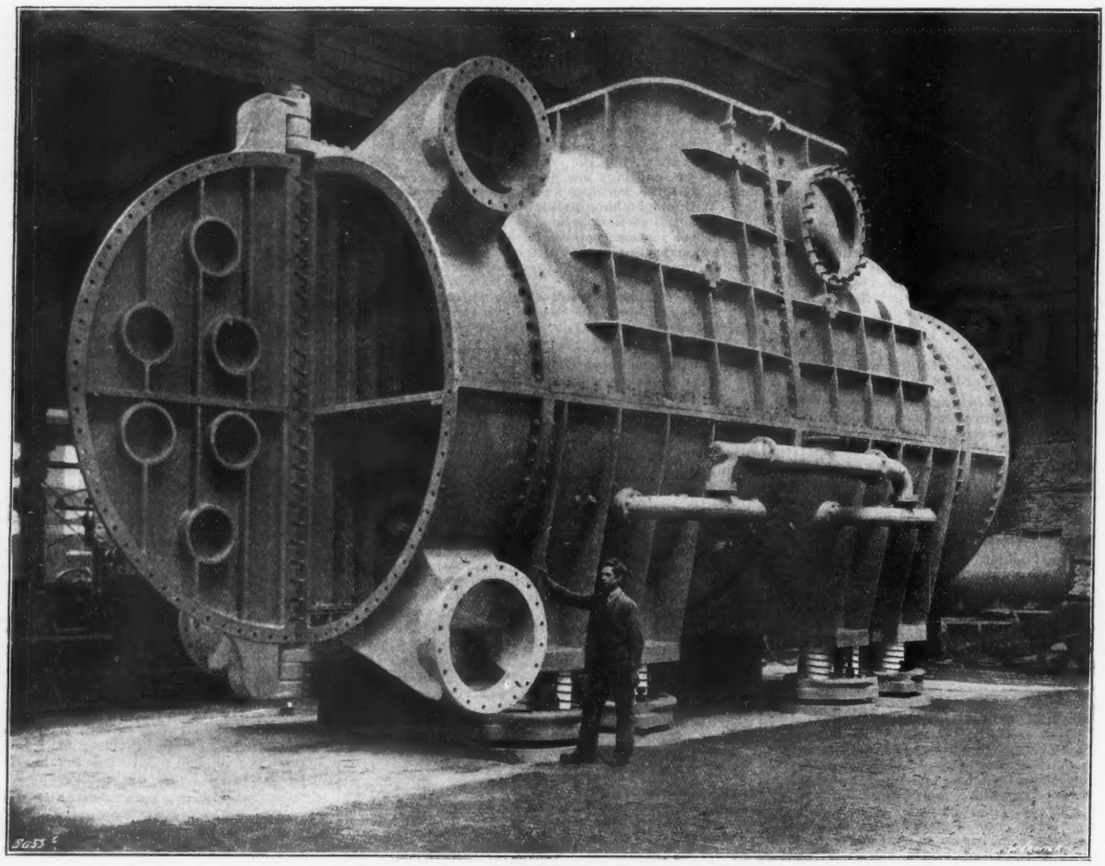


Fig. 7. General View showing Spring Supports.

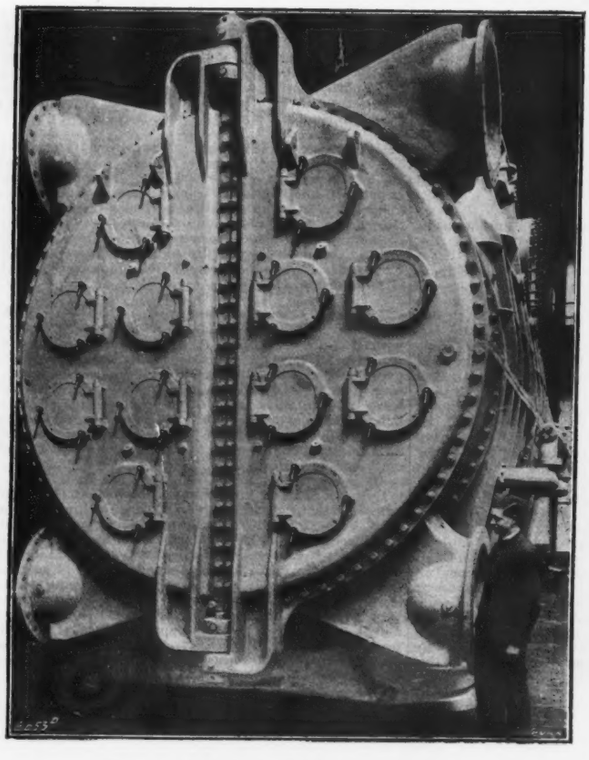


Fig. 8. End View with Doors Closed.

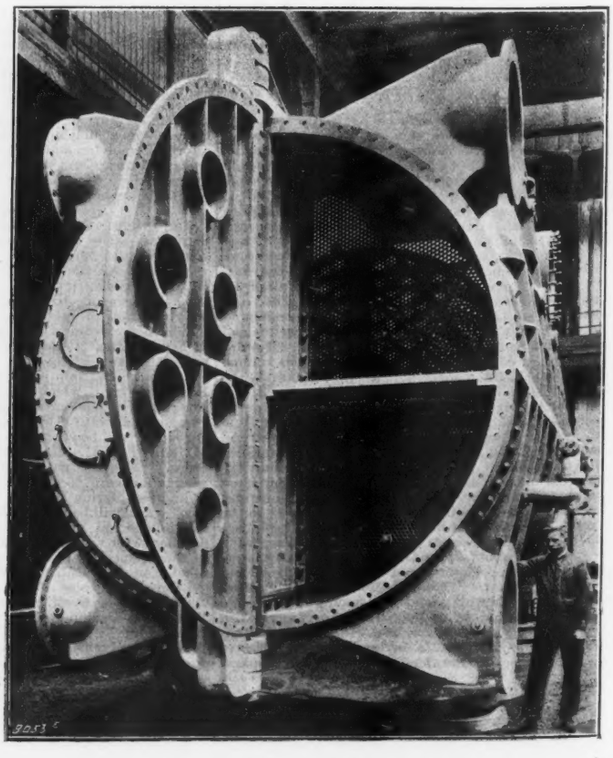


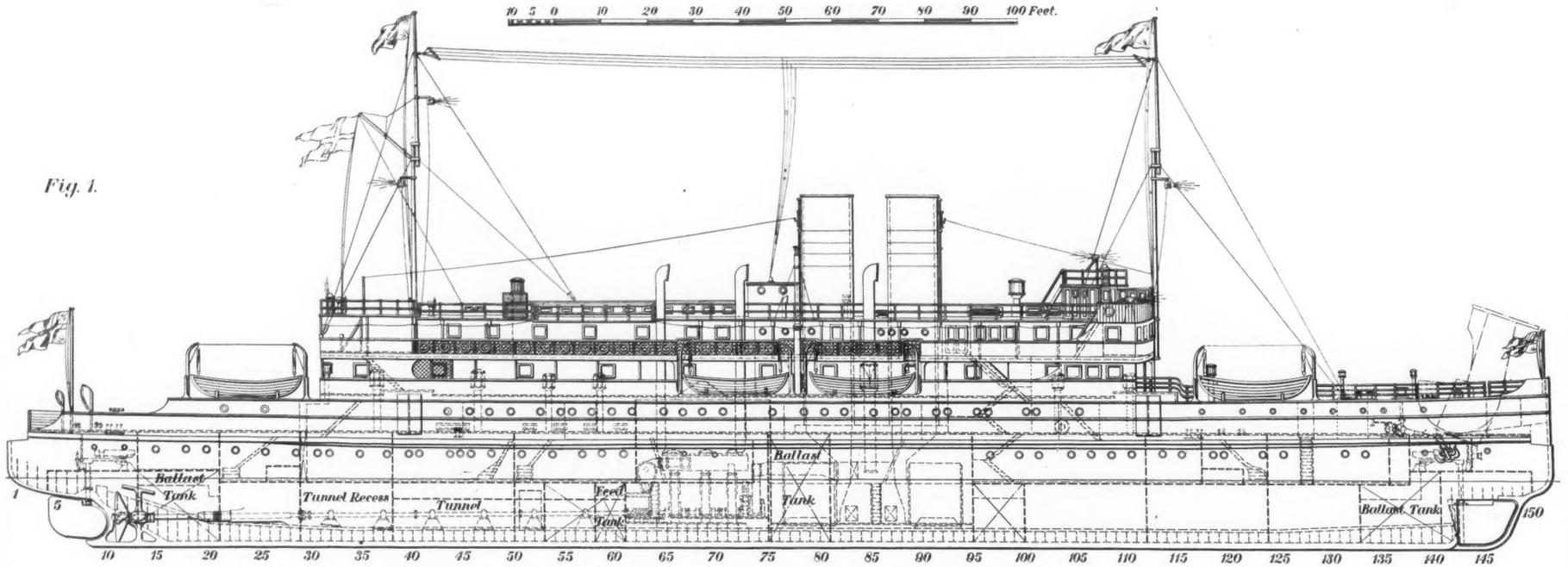
Fig. 9. End View with Half-Door Opened.

THE DANISH STATE RAILWAY STEAM FERRY "DANMARK."

CONSTRUCTED BY THE ELSINORE IRON SHIPBUILDING COMPANY, ELSINORE, DENMARK.

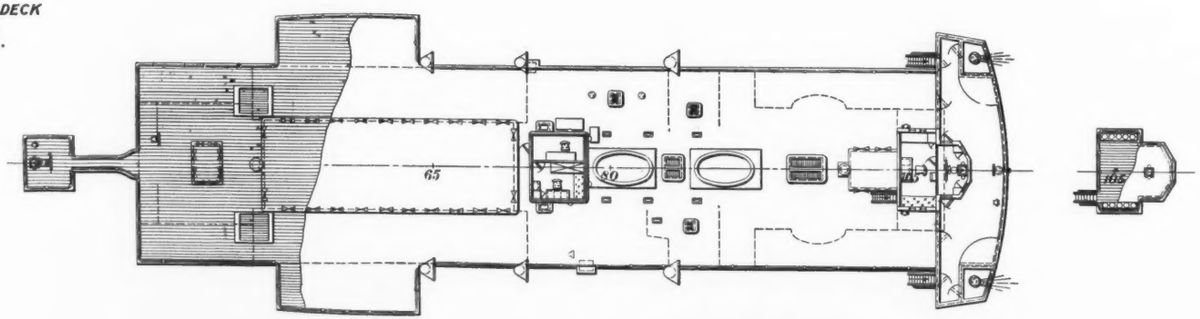
(*For Description, see Page 507.*)

Fig. 1.



BRIDGE DECK

Fig. 2.

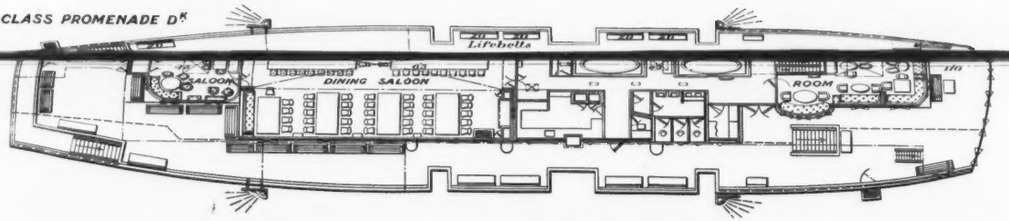


1ST & 2ND CLASS PROMENADE DK

Fig. 3.

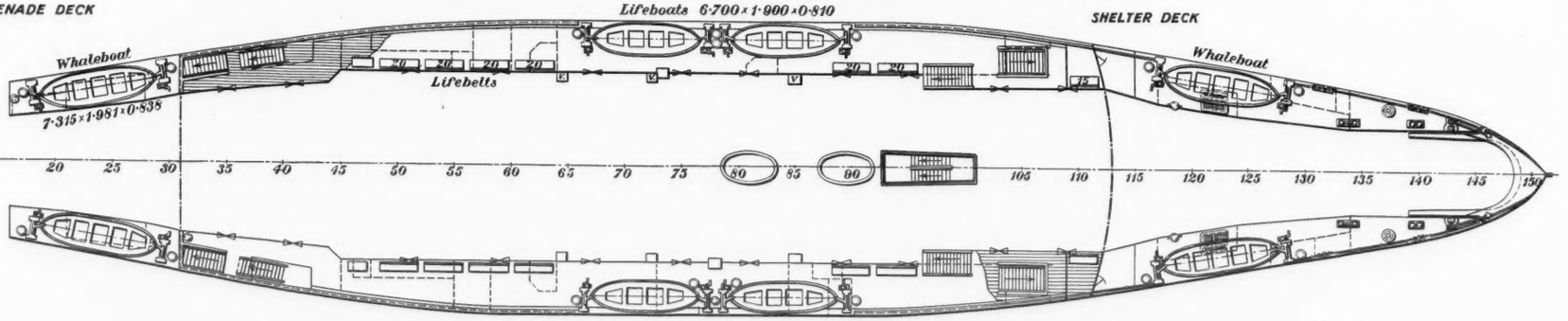
1ST & 2ND CLASS PROMENADE DK

Fig. 3.



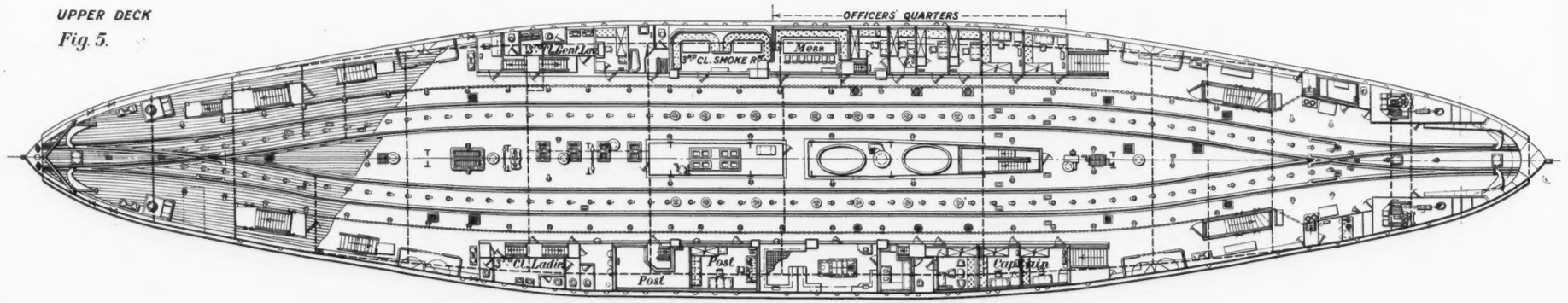
3RD CLASS PROMENADE DECK

Fig. 4.



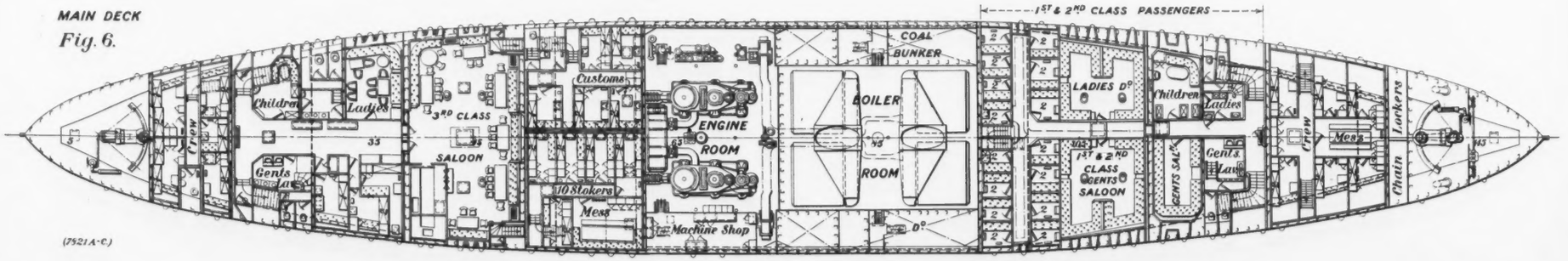
UPPER DECK

Fig. 5.



MAIN DECK

Fig. 6.



(7521 A-C)

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ENGINEERING.

FRIDAY, OCTOBER 19, 1923.

BRITISH ORGANISATION OF RESEARCH.

SCIENTIFIC research has become a fashionable economic prescription. It was recommended first by scientific men, who did not have the power, and in many branches of work would have been wholly incompetent to apply it to industry, and economists have had no difficulty in citing instance upon instance in which discoveries made in this country have been developed and exploited elsewhere. Employment and profit to the value of countless millions of money have accrued to the more enlightened countries, and potential industries have left here to establish themselves for the benefit of more enterprising foreigners. So far as the products of these industries were concerned English manufacturers could procure them from abroad, and the fact that their production supported a population other than our own was not recognised as an industrial disadvantage by the purchasers who could get their necessities supplied.

The war suddenly and abruptly changed this state of things. Products indispensable to the fighting services had to be manufactured here, and methods hitherto secret from even our scientific men had to be worked out. Necessity is the mother of improvised invention, and with amazing success scientific men and manufacturers co-operated to produce what was required. Nevertheless it was known to all concerned that, if such means could satisfy immediate needs, they could assure no permanent progress ; and at the same time as steps were taken to co-ordinate scientific and industrial resources for instant war use, they were extended so as to make a foundation for the more deliberate application of science to industry that would be necessary for civil enterprise.

In this way the Committee of the Privy Council for Scientific and Industrial Research, now more generally known as the Research Department, came into existence in 1915. Its eighth annual report, an account of which will shortly appear in our columns, has just been published, and exhibits more clearly even than its predecessors the organisation and method of working that it has adopted. Though the funds with which it is entrusted are small compared to those at the disposal of similar bodies in other countries, notably the United States, its plans are laid so comprehensively that much in the immediate industrial future of the country turns on the extent to which they succeed. As will be seen shortly, this success depends essentially on the extent to which it secures public and in particular industrial support, and this support can be expected only from a public that understands clearly its objects and methods.

Such an understanding is the more difficult because its methods, like its subject matter, are unfamiliar in Government administration. For many reasons, including some that are said to be partly spiritual and partly anatomical, a Government department, like a limited company, is often exposed to destructive criticism ; but those who have experience of Government departments in this country and in others will be disposed to think that in many essential ways the British Civil Service is the best in the world. Nevertheless, the duties of a Government department differ usually from those of ordinary citizens, not only in the network of regulations by which the service has to be organised, but also in the work itself. The honourable title of a Government official is that he is a civil servant. For the most part the service the State expects of him is his personal work, and though he may work hard and loyally, he often shows the same objection as other workers to being interfered with at his job by those whom he is serving. Sometimes, perhaps, he shows even a little more ; but hitherto he has rarely tried to induce his masters to do the job themselves.

That, however, is the essential characteristic of the Research Department. It does not "hate work and hate them as likes it," but constantly, and with much industry and tact, it seeks to avoid whatever work it can get some one else to do as well. Its primary business, as it conceives, is to get other people and other bodies to do the research they require, and in connection with whatever work it can get done in this way the only duty it reserves for itself is to fetch and carry information where and when it would not be obtained otherwise, and to co-ordinate activities that otherwise might be duplicating each other or missing opportunities for mutual help.

The theory on which the Department has arrived at this conception of its duty—a conception that it expressed from its earliest days—seems to be comprised under three main heads. On the one hand an individual, a works or an industry can value research only to such extent as it knows what research can do, and it can get that knowledge and the necessary interest in what at best is a deferred investment by no other means so well as by assisting in it. On the other hand, increasing familiarity with the results of research must necessarily lead to a wider use of the scientific methods that research involves. The importance of this use of such methods by those who are engaged practically in the industry is the greater because results obtained in the conditions of a scientific laboratory can seldom be applied directly in a works without taking account of much more complex conditions, which as yet are, and possibly always will be, beyond the control of laboratory science. Such application, for instance, to most engineering problems must be made not by the men of laboratory science who tracked out the results in the simplified circumstances of the laboratory, but by men of industrial science, brought up in the complex and inexorable conditions of the works, and yet trained to know and respect the limits that are set by laboratory results. The application of research demands, in fact, the intimate co-operation of those who are engaged in industry scarcely less than the obtaining of results demands the labour of the scientific men to whom they are due.

The third limb of the Department's theory seems to be the conviction that, whether the services that it requires for its own work are those of scientific men or of leaders of industry, they must be taken and renewed from the flowing streams of science and industry, and not from Government ponds cut off

from their springs and flux. It is this conviction to which is due the characteristic organisation of the Department, in which all work with which it is concerned is wherever possible not done by permanent officers of the Department itself, but delegated to the most appropriate persons or institutions that are available at the time. Its Privy Council Committee, its Advisory Council, its multiplicity of Boards, Committees and sub-committees are all recruited not from its own body or from that of the civil service, but from the general body of the community. The entire direction of the Department's work, the choice of problems, the expenditure of funds, the award of grants, the appointment of its executive bodies, lies in effect in the hands of these direct representatives of the community, subject only to the general authority of the Privy Council and the inevitable control of the Treasury. Constitutional lawyers could say how far such a structure can be paralleled in its form in Anglo-Saxon times. To the layman, familiar with the modern temper of the country and having merely common knowledge of its old institutions, it appears to be a singularly British type of organisation.

As will be seen by its current report the insistence with which the Department restricts itself wherever possible to the functions of an enzyme and not of a reagent can be traced throughout the whole of its proceedings, whether in its negotiations with industrial research associations, its co-operation with great professional and other institutions, or its award of grants to university post-graduate students. In such matters its co-ordinating as well as its stimulating function covers in itself a vast amount of service, and should produce a proportionate result. There are, however, subjects with which no amount or strength of enzyme will induce or enable private bodies to handle effectively. The State, for example, is clearly the right body to determine and preserve standards, whether of optical, thermal, electrical or any other physical quantities, just as the Anglo-Saxon State standardised its ell and its pint pot. Some subjects, again, are of interest to so many industries that their investigation, from being every one's business, becomes no one's; adhesives is an example. Many of the most important are too large, require the help of too many sciences, take too long to complete a unit investigation, for private enterprise to be able to face the responsibility with any certainty of carrying it through. When it assumes such a duty it tends almost inevitably to take a short cut where a long fundamental investigation is the indispensable preliminary to successful work; as has been seen, for instance, in the millions spent privately on unsuccessful attempts to carry low-temperature carbonisation of coal to an industrial success. For subjects such as these the State alone has the resources and the inducement to undertake effective fundamental investigations, and to plan research on phenomena that recur only at long intervals.

Still more obviously is it the State's business to explore the extent of national resources and to investigate the possibility of turning them to account or to make better use of them than is made at present. What the full scope of this duty may be depends on the size of the State, and a question that well may be raised at the moment, while the Imperial Economic Conference is sitting in London, is whether the research service has as yet been enabled to take sufficient account of the size of the British State. No purpose is more in the minds of overseas as well as of the home authorities than that of finding ways in which the several parts of the Empire may help each other. There seems to be no way of more importance and promise than the discovery and development of natural overseas resources. Such discovery may result from seeking supplies as yet unknown of natural products that are found elsewhere; but no less important developments may conceivably follow on attempts to turn known products to improved account, or even to turn to account what has hitherto been a waste product or even a pest. In tropical or semi-tropical districts, for instance, wild growths are not uncommon which in the present state of knowledge are simply mischievous, and at the cost of much energy have to be destroyed. Yet there seems to be no reason why research should not find ways of turning at least some such growths into the raw material of useful products. Bio-chemistry and chemistry have doubtless much to do before they will be able to turn prickly pear into motor alcohol, or there may be chemical reasons why it cannot be done. But the consequences of solving such problems would be so far-reaching that few matters can be of more consequence to the prosperity of the Empire and of its constituent peoples than to assure that the organisation for surveying and attacking them is complete, and is working with effect and efficiency.

An essential condition of such efficiency and of the effect that it may be expected to produce is that the work shall be duly and continuously co-ordinated. During the last year it has been questioned whether the Imperial Institute should be made to serve as a clearing house for scientific, technical and industrial information, and during the past several years the Research Department has instituted a registry of the information obtained by its own staff and by those institutions and individuals that have been co-operating with it or working with the help of its grants. The question arises naturally, and no answer is to be found in the Department's last report, whether two clearing houses are likely to be more efficient than one. It suggests further the wide question of whether the research activities of this country are co-ordinated sufficiently with those of overseas authorities. The type of organisation that happily has been adopted for home research allows the fullest possible individual liberty to the units of work that are included in it, and is the better fitted for this reason for being adapted to the co-ordination of research enterprises throughout the Empire. In the absence of such co-ordination it is inevitable that many researches will overlap, so that some work is done twice over. Results that might have followed on allied investigations may be missed, because observations have not been made under comparable conditions, or because the conditions have not been varied intentionally in a way that would yield information from differing results. The attack on a new problem is often like the action of a syphon; it must be full if results are to flow. The co-ordination of two researches may fill the syphon and start its continuing flow, while separately each leg will run off its own contents, and leave the reservoir substantially untapped.

The authorities of the Empire are wisely and anxiously considering the mechanism by which commodities may be exchanged between its States. It is to be hoped that they will not be less concerned to perfect the organisation by which they may be discovered and produced. When all is said and done, the material progress and well-being of a community depends on how much it can induce the earth to yield of its fulness. A far-sighted policy can neglect no means of replenishing and increasing the sources from which materials of production are obtained, and of gaining fresh knowledge of uses to which they can be put. Much of the search after such enlargement of actual Imperial wealth must be conceived and carried out with broad vision, seeking with prolonged labour to explore the foundations of knowledge, so that ultimate progress may be the more assured and complete. The longest way round may often be the shortest way home. Such considerations as these are platitudes while they are not translated into practical action, but when they are, they may become the basis of renewed prosperity and a secure Empire. A necessary condition of realising them as quickly and as effectively as is possible is the adequate organisation of research. The announcement made this week that the subject has been referred to a committee of the Imperial Economic Conference gives ground for the hope that ways will be found for providing more complete co-ordination than exists at present between British research institutions.

THE DEVELOPMENT OF ENGINEERING MANUFACTURE.

In certain branches of the textile trades and, in the manufacture of soap and biscuits this country still may claim to hold the position which tradition would accord to her, but when one turns to the great engineering trades such claims demand careful examination and some modification. In certain lines of work which for convenience one may cover by the term "general engineering" our position is probably as strong as ever. For cranes, steam engines, boilers and other such types of machinery, which are usually built singly or in small quantities, we have no need to look to, or defer to, any other country. When, however, one considers machinery of the smaller type which is produced in large uniform quantities the position is far from equally satisfactory. It is usual to instance the motor car trade when referring to this matter, but motor cars form by no means an isolated instance. The typewriter is a glaring case of an engineering product which for some reason we fail to make for ourselves, and there is no difficulty in finding others. Far too many sewing machines and machine tools are imported into this country. Engineers small precision tools form another case, while as an example of a machine of quite a different order of accuracy one may turn to the lawn-mower with imported examples of which this country is flooded.

It is not easy to understand why the country which invented the factory system has in one important trade so signally failed to take full advantage of the developments to which it has led. There is clearly nothing in our atmosphere or in the mentality of our labour which prevents engineering manufacture in the manufacturing sense being made a success here, as is sufficiently made evident by the position now held by the bicycle and motor bicycle trades. These trades are not only holding their own at home, but are exporting to an important extent. This is as it should be, and it is of very grave importance for our national future that the manufacture of other of the engineering articles which have become of everyday domestic use should develop to the same satisfactory extent. The bicycle trade is an older trade than the motor car trade, and it may be suggested that sufficient time has elapsed for the incompetent manufacturers to be weeded out. These people were doing themselves no good and were spoiling the market for their more competent rivals. There may be something in this, but it is not very satisfactory to have to think that the country which invented engineering requires a generation to find its feet in a new line of manufacture.

There are certainly too many firms manufacturing motor cars in this country at the present time, although even at home there is still a wonderful field awaiting cultivation. Given manufacture on a proper scale and in an efficient manner there is no reason why most of the business which the future will bring should not be kept at home, and there is considerable satisfaction in noting that there are very definite signs of some of our motor car building firms taking something like their proper place in international trade. In very high grade and expensive cars we have always held our position, and it is in the large scale production trade that we do not seem to have been able to attain the level of performance which the development of factory methods have made possible.

In his presidential address to the Institution of Production Engineers, which he delivered last Wednesday evening, Mr. J. D. Scaife suggested that the manufacturing sense of the majority of our engineering employers was poor, and that attempts to combine businesses in this country seemed to have developed on the lines of cutting-out competition rather than on the lines of cutting-out unnecessary costs. We are afraid there is some truth in this. In a trade, working under the conditions under which our engineering trades work, combination in itself is of no value. The fusion of several firms is likely rather to increase than decrease overhead charges, and unless advantage is taken of the combine to concentrate manufacture and improve methods, the last state of affairs is likely to be worse than the first. The methods of a combine are usually dictated rather by commercial men than by engineers, and the policy to which Mr. Scaife referred is probably the natural one for a business man who has no accurate understanding of the manufacturing side of the firms with which he is concerned. The whole blame for the present state of affairs cannot,

however, be transferred to the business man, and it seems certain that most engineers concerned with the motor trade, as with some others, have failed to attain to the manufacturing point of view. This is singularly well illustrated in the motor trade by the failure to develop standard parts and details. This is purely an engineers' matter, and it is only in the last year or so that any attempt has been made on a serious scale to work towards a condition that must form an essential feature of the trade in this country if it is to achieve the position which lies in the possibilities of the future.

The central thesis of Mr. Scaife's address, to which we have referred, was that manufacture pure and simple did not receive sufficient separate study. The engineer was interested in the engine that was made rather than in the machine tool that made it. In some ways this is to the credit of the engineer, but added to that purely engineering interest, it is necessary that we should now develop a larger interest in manufacture itself. This incidentally is, we take it, the purpose of the Institution which Mr. Scaife was addressing. He, however, did not utilise the opportunity to praise his own institution, but went on to suggest that manufacture should be taught, and suggested the founding of a series of scholarships for the purpose of studying the subject. His idea of the course to be covered by such a scholarship was an apprenticeship of about four years in a tool drawing office and tool room, followed by three years made up of consecutive periods of eight months in tool design in a factory drawing office and four months in a university taking lectures in economics, mechanics, shop-system, psychology, &c. The two periods of eight months equipment design would be spent in different factories.

This suggestion by Mr. Scaife is interesting, and although we are afraid it is hardly likely to lead to the immediate founding of any such series of scholarships it will help to direct attention to a really serious aspect of our engineering trade. The laying down of a plant for engineering manufacture in a modern sense is an expensive matter, and any ventilation of this subject will to some extent help in the very necessary education of the men who control the funds. Apart from any benefits which might follow from the general recognition of manufacturing methods as a proper subject of study and education there is another agency which may help the engineering trades of this country towards a better appreciation of the possibilities that lie in front of it. This agency is the school of experience. Hard though it may be, the period of low employment and restricted trade through which we are passing has done, and is doing, much to bring some of our manufacturers to a realisation that in many ways older methods must be abandoned and modern workshop possibilities embraced and employed in their stead.

METAL VACUUM VESSELS AND LIQUEFIED GASES.

SIR JAMES DEWAR'S researches on the occlusion, adsorption or absorption of gases at various temperatures on or in charcoal and other substances, and his discovery of the extraordinary length to which these processes could go with appropriate substances at very low temperatures, make a remarkable instance of investigations having initially only a theoretical interest which rapidly proved to have a direct application in practice. The limits of that application do not seem by any means to have been yet reached, but the Report just published by the Oxygen Research Committee of the Scientific and Industrial Research Department* presents in its 172 pages a useful stocktaking of what progress has been made up to now in both theory and practice, and an account of the state to which the researches made for the committee have brought practice at the present time.

The subject is one with a particular interest to engineers. The most important liquefied gases—oxygen and nitrogen—are essentially engineering products, made by purely mechanical processes, and liquid oxygen, if it could be produced at an economical price, would be applicable to engineering as well as to chemical and medical purposes. To what extent the cost of production may ultimately be reduced cannot yet be forecasted, nor has the present committee been concerned with that aspect of the problem. Its attention has been directed to methods of using it, and the first direction in which it has seen reason to seek improvements has been the construction and use of vessels in which such a liquid can be contained and transported conveniently and without undue loss.

It is not unnatural that the evolution of a practice of handling the liquid gases that formerly were thought to be permanent should be slow, for until they had been produced no such liquids had ever been met with. Liquid air, for instance, is somewhat lighter than water—liquid oxygen rather heavier, and liquid nitrogen about as much lighter—with an enormously higher coefficient of expansion, boiling at — 194 deg. C. with a latent heat of vaporisation less than a tenth of that of water, and requiring about an equal amount of heat to raise the gas that evolves from its boiling-point to 0 deg. C. In other words, a liquid that boils at a temperature far below anything met with in ordinary practice, and, compared with ordinary liquids, vastly more sensitive to changes of temperature. In good vacuum containers holding 1 litre to 25 litres from 20 per cent. to 5 per cent. or more boils away per day, according to the size of the vessel; the loss is about the same whether the vessel is full or nearly empty. With magnesia lagging instead of a vacuum jacket it is calculated that to keep the daily loss through evaporation down to 20 per cent. would require a cylindrical vessel of 500 litres capacity. Only in exceptional cases are such quantities of liquid air required, and only for quite short periods could such a loss be tolerated. The primary problem in storing liquid gases is accordingly to design and manufacture vacuum vessels that can be used conveniently in practice, and that allow the smallest possible access of the atmospheric heat to which these considerable losses are due. In practice the evaporative efficiency of a vessel is expressed by the volume of gas at normal temperature and pressure evolved per minute, which is 665 times the volume of liquid air evaporated and just under 800 times that of liquid oxygen.

Among the first business of the committee was, therefore, to work out a means of predicting from a vessel's material, dimensions, and jacket vacuum the rate at which liquid gas would evaporate from it. In the course of an excellent general description of vacuum vessels and the theory of their action as storage vessels for very cold liquids, based largely on monographs by Dr. J. A. Harker and others, it is shown that radiation across, and conduction through, residual gas in the jacket and conduction down the neck are the most important ways through which heat can enter a vacuum vessel; and indeed the heat conducted down the neck is mostly or wholly absorbed in warming the gas as it escapes, and does not therefore affect the rate of evaporation. For given temperatures of the walls of the jacket the loss through radiation depends largely on the emissivities of the surfaces, which are themselves affected not only by their material and temperatures but also by the state of their reflecting surfaces. Strictly calculated, the heat that passes by radiation is a multiple of the difference between the fourth powers of the temperatures of the outer and inner jacket walls; but as in fact the temperature of the outer wall is somewhere about 273 deg. absolute or more, while that of the inner wall is somewhere about the boiling-point of the liquid—say, 91 deg. absolute or less—the precise temperature of the inner wall has a negligible effect on the radiation loss compared with that which arises from even small fluctuations in the temperature of the atmosphere, with which the outer wall is in contact.

At ordinary pressures, down to vacua that for many purposes would be high, the loss by conduction across the vacuous space would vary inversely with the thickness of the layer of attenuated gas in that space, and be practically independent of its pressure. When, however, a sufficiently high vacuum has been reached this loss becomes independent of the thickness of this layer—*i.e.*, of the annular width of the jacket—and varies approximately with the pressure.* For an annular width of jacket of about 1 cm., the evacuation must reduce the pressure to the order of 0·01 mm. before the conductivity will be notably affected, or to 0·1 mm. for a width of 1 mm. From this point the conductivity falls as the vacuum increases. At pressures of 0·0001 mm. or less, which are now attained in ordinary practice, the loss by conduction across the vacuum jacket is substantially less than the loss through radiation; in a 4-litre vessel, for instance, the loss by radiation was found to be twice to three times as large as the loss by conduction. In pressures of a tenth to a hundredth of this amount, which can be produced without difficulty, the loss by conduction is trifling or even negligible.

These results, among others, were verified experimentally for the committee by Professor Henry Briggs, and important experiments on adsorbents were carried out for the committee by him and by Mr. B. Lambert. Much as Dewar found, the best results were obtained from nut shells or fruit stones carbonised to charcoal and then "activated" by heating for some hours in retorts at 800 deg. to 1,000 deg. C., or by the action of steam in one or other of a variety of processes. In a series of experiments on various adsorbents at liquid-air temperature and atmospheric pressure, Professor Briggs found that an activated cocoanut charcoal adsorbed 129 times its volume of dry nitrogen—chosen as a constituent of air that is chemically indifferent to the adsorbents—while an activated silica prepared by a method worked out in the course of the investigation adsorbed 203 times its volume. Parallel experiments with dry hydrogen gave much lower adsorption by the silica than by the charcoal, an indication that the action of adsorbents on gases is selective, which was borne out by results with a number of other materials and gases. At high vacua, on the other hand, the silica was inferior as an adsorbent to the charcoal for all gases tried.

Mr. Lambert's experiments on a number of adsorbents established that the direct variation of pressure and volume of gas adsorbed at a given temperature—*i.e.*, the straight-line form of the adsorption-pressure isotherm—ceased for very low pressures, say below 0·01 mm., and the rate of adsorption became proportional to the pressure for the time being. For the range of pressures in these experiments (0·1 mm. to 10 mm.) the reduction of pressure that a given volume of adsorbent ultimately effects in a given vessel is usually less than proportionate to the original pressure when the adsorbent was first exposed in connection with the vessel, and practically never much greater. This result confirms Brigg's statement that to obtain the highest vacua adsorbents must be applied in separate bulbs in series, set successively to start on the pressure to which the previous bulb or bulbs had reduced the gas in the space under exhaustion.

While the relation of degree of exhaustion to mass of adsorbent has not yet been worked out, the proportion usual in the manufacture of vacuum flasks is several times as large as in Mr. Lambert's experiments, in which pressures of the order of 0·0001 mm. were obtained from original pressures of 1 mm. When any sort of likely allowance is made for the much larger ratio of adsorbent to volume of jacket thus used in practice, these experiments explain clearly how it comes that with a usual charge of palm-nut charcoal a pressure of 0·1 mm. in the vacuum space of a 50-lb. (about 25-litre) container is reduced to about 0·000002 mm. when the vessel contains liquid air (the adsorbent being cooled by contact with the inner wall of the flask), or a pressure of 1 mm. to about 0·00002 mm. They also confirm

* Report of the Oxygen Research Committee. H.M. Stationery Office, 8*s.* 6*d.* net.

* This is explained on the kinetic theory of gases by the fact that the mean free path of molecules in air, which at N.T.P. is roughly 10^{-5} cm., varies inversely with the pressure, and will thus become 1 cm. when the pressure is reduced to 10^{-5} atmospheres, or, say, 0·0076 mm. When the mean free path is equal to, or greater than, the annular width of the jacket, most of the molecules will run their full course without colliding with each other, and for a given annular width will thus convey heat in proportion to their number, which varies with the pressure of the gas. Thus, if a very low pressure is halved, the number of molecules and the transfer of heat will also be halved; while if the pressure remains constant but the annular width is doubled, the number of molecules in the space as well as the length of their path are doubled simultaneously, and the rate of transfer of heat remains therefore constant.

independently the conclusion that the evaporative loss of liquid air in a serviceable Dewar flask is due mainly to radiation and relatively little to conduction, and explain how in service, with its adsorbent cooled by its contents, a flask exhausted roughly to 0·1 mm. or 0·5 mm. can have an evaporative rate as low as a similar flask originally evacuated to a high vacuum.

The preparation of flasks with silica adsorbent to give almost the same evaporative efficiency as with activated charcoal involved special precautions and the use of a higher vacuum, the cooling of the adsorbent by the liquid having less effect in increasing the adsorbent power of the silica than that of the charcoal. The silica prepared by Professor Brigg's method is, however, much more efficient than other varieties of silica used in the same series of experiments, and the use of silica as an adsorbent is of practical value when the flask is exposed to the risk of accident—*e.g.*, perforation by a bullet—which would flood charcoal with liquid air and thus cause an explosion.

A series of investigations on the mechanism by which the gases are occluded—how, for instance, charcoal that at atmospheric pressure and room temperature occluded 6·4 times its volume of nitrogen occluded, when it was cooled in liquid air, over 110 its volume of gas measured at the same temperature and pressure—gave results not inconsistent with previous hypotheses of the distribution of the total occluded gas (recently proposed to be called "sorbed") between what was adsorbed at the surface and what was absorbed in the interstices of the charcoal. Some increase of volume of gas stored in a given cylinder could be obtained by first filling the cylinder with charcoal; at 35 atmospheres the gain was about 66 per cent., but at 110 atmospheres only 10 per cent. It is estimated that about a third might have been added to the increase if the charcoal had been forcibly compressed into the cylinder; but the total gain at 120 atmospheres, the usual pressure at which commercial cylinders are charged, does not seem likely to be considerable. When the adsorbent was charged by immersing the cylinder in liquid air, instead of as in the above experiments by direct pressure, the pressure rose to 50 atmospheres and to 70 atmospheres on the cylinder being allowed to resume room temperature. Some saving in the energy required for charging might thus be obtained. Presumably some investigation would have to be made of the effect of the process on the toughness of the cylinder.

Progress in the manufacture of metal vacuum vessels has been considerable. As late as 1919 the Air Ministry accepted vessels up to 5-litre capacity of which the rate of evaporation was 1 litre per minute; at present the limit is 0·5 litre, and 0·3 litre can be obtained quite well in commercial manufacture. Accepted vessels, moreover, often broke down in use, and had but a short life, whereas much improvement has now been made in these respects. To some extent the original defects arose from want of knowledge of what details were important. Loose polishing powder and charcoal on the polished surfaces increased their emissivity, fluxes almost invariably corroded the cupro-nickel necks, imperfect drying left a film of water that prevented the necessary high vacuum from being obtained, joints were leaky. The improvements that have been adopted as the result of prolonged researches relate partly to design and partly to the method of evacuation.

As is natural, the improvements in design have consisted of attention to numerous points of detail. At present, after a variety of other materials had been tried, copper spinnings are used for the bodies, apparently because of the effect on evaporative rate of the high polish of which they are susceptible. Having regard to the considerable effect that seems to be exercised by materials of high conductivity in increasing evaporation—silica, for instance, which the report seems to regard as the most promising vitreous material except for its cost, gives a very much higher rate of evaporation than glass—it may be hoped that further research may find some single metal or alloy, or some welded composite metal, that will give a surface and a relative impermeability equal to those of copper with a much lower conductivity. A principal trouble has been to get sound joints, for the equatorial joint may be as long as 7 ft., and considerable strain may come on the joints at the neck of the inner vessel and the junction between the two necks if they are imperfectly designed. These lead not only to leaks but to contact between the two walls of the jacket when the vessel is made and consequent short-circuiting of the flow of heat. The difficulty of securing the adsorbent in position so that it is in contact with the bottom of the inner vessel but not with its contents, has been got over by using a suitable copper-backed capsule, to be soldered on to the bottom; and this construction enables the capsule and charcoal to be heated and kept in a desiccator till it has to be fixed, when it can be secured rapidly in position before it absorbs moisture from the atmosphere. An improved arrangement for sealing-off through a lead tube has also proved satisfactory, and details have been worked out of composition and method of applying the solder and other operations in assembly and of testing for soundness during manufacture before assembly of the outer spinnings, before final evacuation, and before and after repair.

Of these tests, the most important is made with a special differential oil manometer, either before or during the final evacuation. It turns on the fact that a leak or very small hole in a wall separating gases at equal pressure causes no change in the pressure, but with a constant difference of pressure causes on one side of the wall a rise of pressure varying directly with the time, so that a pressure-time graph will be approximately a straight line. Thus with the jacket evacuated and the pump disconnected by a clip the pressure is plotted against the time, and if the graph is not horizontal but an inclined straight line the inner vessel is evacuated. If the graph continues unaltered in direction, the evacuation of the inner vessel has not affected the course of pressure in the jacket, and the inner vesesl is therefore sound. If, on the other hand, the graph has become horizontal after the pressures in the vessel and jacket have become equal, there is a hole in the inner vessel, which must therefore have leaked. Indications such as these, confirmed by similar observations under pressure, enable the leak to be located, or give a clear suggestion of any emission of gas or vapour, which would tend in time to get less and thus flatten the graph.

This test is regarded as a first and important stage in the evacuation; but a still more important improvement in the process has been due to the recognition of the fact that the rate of final evacuation is limited not by the size of the pump but by the rate of escape of gases from the adsorbent within the vessel. In practice this adsorbent is kept heated during the evacuation either by steam within the inner vessel or otherwise; the temperature is about 100 deg. C., and would be carried much higher but for the soldered joints. It has been found that the gases in an adsorbent so circumstanced escape so slowly as to make very little difference to the pressure in the exhausted vessel until some time has elapsed, when a very short spell of pumping will reduce the vacuum to its previous value, and the pumping can again be stopped without affecting the rate at which gas escapes from the adsorbent. It has also been found that the gas escapes practically as fast under a pressure of 1 mm. to 2 mm. as under a higher vacuum, say 0·01 mm. The report gives a large number of directions and cautions derived from the committee's researches and experience, which evidently would be useful and even necessary whatever process of evacuation was being used. But the really salient achievement in the process of evacuation appears to have been the discovery that large pumps and continuous pumping are useless as well as costly, and that exhaustion of gases from the adsorbent and the walls of the vessel has gone as far as is necessary if the vacuum while the vessel is in service and the adsorbent therefore at about the temperature of liquid air is of the order of 0·0001 in. of mercury or less. As pointed out above, this may mean a pressure during evacuation of anything up to 1 mm. or more. It is perhaps too early to say that the extent to which the adsorbent and walls of the vessel are freed from residual gases has no effect on the useful life of the vacuum; but the economical advantage of discontinuous pumping, and the consequent elaboration of a method of evacuating a series of vessels in parallel, seem likely to be a permanent enhancement of the value of evacuating plants. It has in fact already enabled six vessels to be exhausted with a smaller pump and with little more time than formerly was needed for one.

Some investigation has been made of the rate at which vessels lost their vacuum with and without adsorbents. The general effect of the results is to show that while evaporative rates seem to be increasing gradually during the life of the vessel after exhaustion, the rate of increase is not great when charcoal or silica adsorbents are used, and there is little difference between these materials provided the vessel with the silica adsorbent has been evacuated with the necessary greater completeness. From the construction of the vessels it seems unlikely that adsorbent particles can have got loose and so increased the emissivity of the walls, but it has not been determined to what extent the rise of evaporative rate is due respectively to evolution of gas or gases from the walls and adsorbent and to percolation. The evaporative rate of a vessel without adsorbent has risen steadily and more rapidly than those with adsorbent. On the whole it is said to be likely that well-made vacuum vessels with charcoal should retain their vacuum to a serviceable extent for at least several years; but further investigation is in progress.

Transport adds to the evaporative loss in any case by swaying of liquid, and sometimes by short-circuiting of the heat circuit through the vessel and jacket vibrating into contact and by leak arising through strain on the neck joints. Some results are given to illustrate the total increase of loss that may arise on various methods of conveyance, but these do not seem very conclusive, and experiments are proceeding. An appendix to this very valuable report gives a considerable number of physical data in regard to liquid oxygen, nitrogen and air to which reference had to be made in the course of the investigations. These add considerably to the ease with which the report can be intelligently followed.

LIGHT AEROPLANE TRIALS AT LYMPNE.

Although the competitive trials of low-powered aeroplanes, which were concluded on Saturday last, the 13th inst., at Lympne, were not favoured with very satisfactory weather conditions and were marred on the final day by a fatal accident, the results obtained were sufficient to indicate that these little machines may be developed into really useful means of transport. The trials were organised by the Royal Aero Club, and the main prize was one of 1,000*l.* offered by the proprietors of *The Daily Mail* for the greatest distance flown on one gallon of petrol, the engine used to have a cylinder capacity not exceeding 750 cub. cm., and a minimum distance of 50 miles being stipulated. This prize was open to competitors of any nationality, but an additional prize of 500*l.* was offered by His Grace the Duke of Sutherland for the greatest distance flown by a British pilot on a British machine, with the same quantity of fuel. Other prizes were offered for the highest speed and height obtained and for the greatest distance flown during the trials. Altogether 28 entries were received, the majority of the machines entered being monoplanes, although the number included five of the biplane type; most of the engines fitted were of the motor-cycle type.

The trials commenced on the 6th inst., on which day the machines were tested for facility of transport on the ground. For this purpose the stipulation was that the machine must pass through a 10-ft. gateway, must not occupy a road width of over 7 ft. 6 in., and must be capable of being wheeled for a distance of 1 mile by two men. All the machines present passed this test satisfactorily. The flying tests commenced on Monday, the 8th inst., and were continued throughout the week except at times when the weather conditions were unfit for flying; on Friday, the 12th inst., for instance, a heavy gale rendered flying quite impossible.

As a result of the tests, the prizes for the maximum distance flown per gallon of petrol had to be divided between two pilots, both of whom covered 87½ miles with that quantity of fuel, flying on a triangular course, having a total length of 12½ miles. The

winning machines were the Wren monoplane piloted by Flight Lieutenant W. H. Longton, and entered by the English Electric Company, Limited, and the A.N.E.C. monoplane, piloted by Mr. J. H. James, and entered by the Addlestone Aeronautical Association, Limited. The first-mentioned machine, which was designed by Mr. W. O. Manning, was fitted with an A.B.C. motor-cycle engine having a cylinder capacity of 400 cub. cm. and rated nominally at 3 horse-power. In the A.N.E.C. machine, which was designed by Mr. H. S. Shackleton for the Air Navigation and Engineering Company, of Addlestone, a Blackburne engine of 700 cub. cm. cylinder capacity was mounted in an inverted position in the nose of the fuselage. It will be noted that with petrol at 1*s.* 6*d.* per gallon, a mile can be travelled on either of these machines at a cost of just over 0·2*d.* for fuel.

The A.N.E.C. machine also attained the greatest height recorded in the trials, viz., 14,400 ft., the pilot on this occasion being Mr. Maurice Piercey. The same machine, it may be mentioned, took second place in the speed contest, reaching 74 m.p.h., and also took second place for the prize awarded for the greatest total distance flown, its record being 775 miles. The greatest speed was attained by a Parnell-Pixie monoplane, piloted by Captain Norman Macmillan, whose record was 76·1 m.p.h., measured over two laps of the triangular course. This machine is fitted with a Douglas motor-cycle engine having a cylinder capacity of 500 cub. cm. Mr. B. Hinkler, flying an Avro monoplane fitted with a Blackburne engine, obtained the prize for the greatest distance covered, having flown a total distance of 1,000 miles during the week.

It was in connection with the altitude contest that the fatal accident, above referred to, took place. M. Alex Maneyrol, the French pilot who won the competition for gliders at Itford Hill last year, as recorded on page 529 of our 114th volume, crashed from a height of 150 ft. in descending from an altitude flight. The accident appears to have been due to the collapse of the wings of the machine he was flying, which was a Peyret monoplane fitted with a Sergant engine. Early in the morning of the same day M. Maneyrol had reached a height of 9,400 ft. in this machine.

The results recorded above are, of course, the best obtained during the course of the trials, but good performances were also put up by several other machines present. They certainly demonstrate the possibility of flying economically at fairly high speeds by skilled pilots. If machines with equally good or improved performances could be designed to be safely controlled by less experienced persons, the market for them, both in this country and abroad, would doubtless be sufficient materially to assist the aviation industry, especially as quantity production would greatly decrease the first cost. In any case, it would appear to be desirable to develop a low-powered two-seater machine with dual control for instructional purposes, and in this connection it is interesting to note that the Air Ministry proposes to offer a prize for a light two-seater machine to be competed for next year.

NOTES.

The Manchester Association of Engineers.

The season of presidential addresses is again with us, to be followed immediately by the usual winter sessional meetings of our various technical societies and institutions. A presidential address is usually allowed some latitude, and advantage was taken of this by Mr. Cecil Bentham in his address on Friday last before the Manchester Association of Engineers to make some remarks upon a point too often lost sight of by engineers. We refer to the lucid verbal expression so often required of an engineer but so seldom met with. At the beginning of a winter session Mr. Bentham's remarks are opportune, for the majority of the speeches to which members of institutions are compelled to listen, are certainly not attractive. It frequently happens that something quite interesting in itself is lost sight of owing to the inattention resultant upon a bad or too prolix a form of delivery. A short, carefully prepared contribution made while the attention of the audience is still attracted by the change of speaker, will have better effect than any point of a drawn-out speech. It is only complimentary to a meeting to go to a good deal of preliminary trouble to make one's remarks effective, but this, of course, does not of necessity involve occupying much of the available time. As the Manchester Association is fortunate in its Secretary, Mr. Bentham had no cause to add, as he might otherwise have done, that much can be achieved by secretaries to make meetings interesting, notably the actual reading of papers. Few authors have experience of public reading, and in many cases it would be quite worth while for them to enlist, through the secretary, the services of someone who could do this part well, and thus save the audience much irritation. On more technical matters, Mr. Bentham's address touched upon, as was natural in so important an industrial centre as Manchester, the present position of trade and the immediate prospects. He pointed out that the position is affected by the large works erected for war purposes, which have resulted in over-capacity. With a certain amount of redundant plant in the country it is to be expected that only those firms which are well equipped and organised will survive the acute competition which must set in when trade revives. The constant development of new markets and new lines is thus of extreme importance, and no firm can afford to rest satisfied with its own business in any particular branch or sphere.

Some Results of Inventive Work.

The presidential addresses to our institutions give a very good opportunity for showing what men of our race have contributed in whatever field of service they have devoted their life work. It is for this, if for no other reason, that we must congratulate Mr. J. Howden Hume for the excellent address he gave to the Institution of Engineers and Shipbuilders in Scotland on Tuesday last upon the work of his uncle, James Howden, in the introduction of forced draught to boilers. In 1882, when the system was brought to a successful issue, the inventor was able to state that, after exhaustive inquiry in both the Old and the New World, not one case was found in which the older schemes or any modification of them was in actual use in a mercantile vessel. Savings effected through the introduction of the regenerative method of air heating and forced draught, though it cannot be calculated, must be gigantic. No excuse is therefore necessary for the devotion of a presidential address to the work of a pioneer whose efforts conferred such a boon on the engineering world, and especially when it was delivered to an institution of which he was one of the founders. That the inventor was an original thinker of a most exceptional nature is evidenced by the statement made by Mr. Howden Hume regarding the suggestion of the use of triple expansion in steam engines by James Howden in a patent he took out in 1860. It is to be regretted that no actual application of the system proposed in that patent was made before the expiration of the patent. The first experiments he made in the use of forced draught were conducted in 1862. Those tests, with a fan blowing air into a closed ash pit, showed that when complete combustion was obtained with thin fuel beds a great reduction of evaporative efficiency was found and, also, that as the beds were made thicker, to prevent the air passing through too freely, the combustion was imperfect. On the conclusion of the trials, James Howden formed the opinion that no advantage could accrue from increased combustion over the rates obtained with natural draught by the system he then proposed, which would compensate for the disadvantages arising from the difficulties in working. Early in 1880, however, after much thought and careful experimenting, he designed the arrangement, which, with slight modifications, has been so successfully adopted and the nature of which is universally known. The application of the system later to oil burning was similarly treated, historically, by the president, and examples of its early use cited. The latest application of the system in combination with a mechanical heater has been the subject of a great amount of recent test work, and the results are to be presented in a paper by Mr. W. H. Owen to the Institution. In this address of Mr. Howden Hume we have a permanent record of the history of a great achievement.

Plans for the Relief of Unemployment.

The Minister of Health and the Minister of Labour have made statements during the week with regard to plans which have been drawn up in connection with the prospective unemployment in the coming winter months. From these it appears that a great deal of work is to be brought forward in connection with roads and bridges, both of these being directions which will also involve activity in the steel and engineering trades, and the cement and other industries. Dealing with the general steps which have been taken to stimulate industry, Sir Montague Barlow announced that the State export credit scheme still had 16,000,000*l.* available for use, while in connection with the Trade Facilities Act guarantees had been given to the extent of 36,000,000*l.* out of 50,000,000*l.* An additional 10,000,000*l.* had been allotted to Lord St. David's Committee and the terms of grants re-drafted with beneficial results. The total new expenditure involved under the schemes proposed amounted to about 50,000,000*l.* The programme of relief works which involved about 27,000,000*l.* had been extended to bring the total expenditure up to about 40,000,000*l.* Under the latter many important road connections will be put through. Of the total sum about 14,000,000*l.* will be spent in London and the neighbouring counties. The London and Hastings road will be completed; a new road is being built from Glasgow to Edinburgh, and it is probable that a new road from Manchester to Liverpool will also be taken in hand. The reconstruction of no less than 150 bridges is contemplated. Many of our roads pass over bridges which are not up to modern requirements either as regards accommodation or strength. There is an ample field for useful work in this direction. The bridges are to be re-built in steel or reinforced concrete, and though many of them will be of the lesser sizes the total materials involved will be considerable and the orders for these will be very welcome. A new steel bridge is planned across the Dee at Queensferry, to cost 100,000*l.*, and an entirely new bridge across the Tweed at a cost of about 200,000*l.*, while a two-mile road bridge costing in the neighbourhood of 1,000,000*l.* is to be carried across the Tay. The orders for steel required for these and other works will amount to about 2½ millions sterling. The railways have planned a good many important works. These will involve on the London and North Eastern Railway an expenditure of 150,000*l.* on the reconstruction of two swing bridges, and 153,000*l.* on coal staithes at North Blyth, with many other smaller works. The Great Western Railway has also formulated a programme which involves new works to the cost of 4,500,000*l.* The two companies between them have planned expenditure which will run to between 10,000,000*l.* to 15,000,000*l.* The orders will include rolling stock, stores, reconstruction of tips, and electrification of the suburban lines on the north of London. The London Underground Railways, which have already received a grant of 6,000,000*l.*, are to have this extended by another sum of equal amount under the Trade Facilities Act. 2,600,000*l.* is set aside under the same Act in connection with shipbuilding; the North Wales Power Company is receiving a guarantee up to 1,600,000*l.*, and Messrs. Tata a guarantee of 1,000,000*l.* It may be mentioned that the Government intends that all material and work in connection with the foregoing grants, &c., should be British, and Sir Montague Barlow stated that it was prepared to take any steps necessary to prevent the use of "dumped" products.

THE CYCLE AND MOTOR-CYCLE SHOW AT OLYMPIA.

The Ninth International Exhibition of Cycles and Motor-Cycles at Olympia was opened on Monday last and will remain open until Saturday, October 20. As it is just fifty years since the cycle trade was started, it is interesting to note that the position of supremacy then established has been maintained

EXHIBITS AT THE CYCLE AND MOTOR CYCLE SHOW AT OLYMPIA.

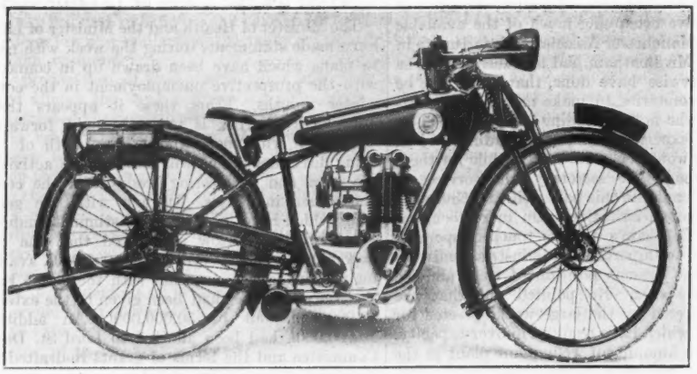


Fig. 1. 2½-H.P. Rover Motor Cycle; Rover Company, Limited, Coventry.

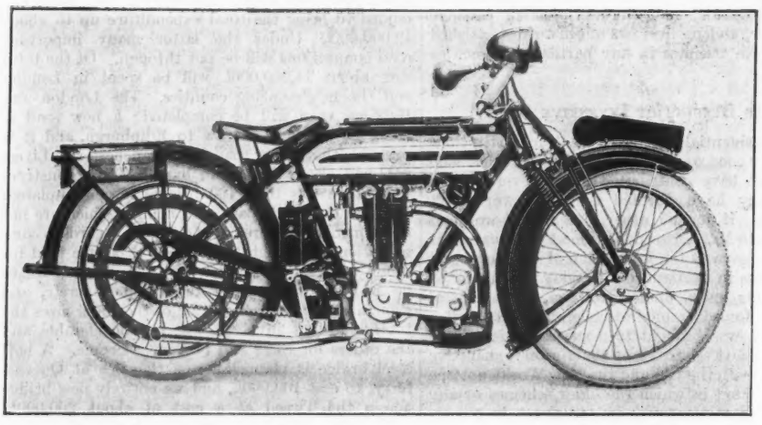


Fig. 3. 3½-H.P. Triumph Fast Roadster with Ricardo Engine; Triumph Cycle Company, Limited, Coventry.

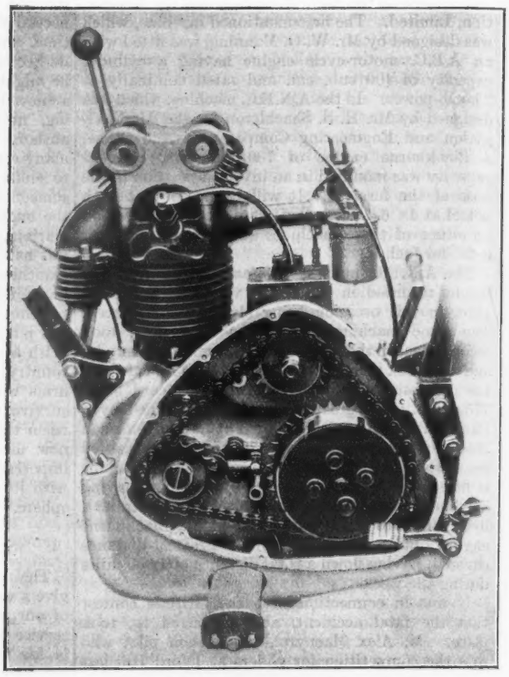


Fig. 2. Rover Engine Showing Chain Drive.

throughout the half-century. To-day there is a large exportation not only of complete machines but of components and fittings, and the industry is in a very healthy state. During the first nine months of this year the British motor-cycle exports have increased no less than 45 per cent. One of the most outstanding characteristics of this year's exhibition is the reduction in prices. It applies not only to push bicycles, but also to the motor-propelled machines of every size and type and to components. In fact, it may now be claimed that prices have been reduced below the levels prevailing immediately before the European War. This has been brought about by the reduction of production costs effected in the workshops. The fears of foreign competition in this industry are now almost reduced to the vanishing point.

The show is without question the most representative ever held and even includes examples of the new field to which motor-cycle engines have been successfully applied, that of light aeroplanes. The exceptional results obtained at the recent tests at Lympne are testimony not only to the successful design work in the aeroplane, but also to the reliability and efficient running of standard motor-cycle engines. Two of the machines with which awards were won at Lympne are available for inspection in the show, while examples of the engines may also be seen on the stands of the makers of the Blackburne and Douglas engines.

The general design of motor-cycles, having now reached the stage when a high standard of excellence has been obtained, shows but little change. It is true there are some improvements, but they are connected with details or modifications suggested from the standpoint of production. Some years ago a great future was predicted for the three-wheeled vehicle as an intermediary between the motor-cycle and the car. If the number of exhibits of that type of machine is to be taken as an index it must be owned that the development has been very slow. The ability to deal with the special problems in design connected with three-wheeled vehicles has not, however, been lacking, for there are in the show examples of conspicuous merits of which the T.B., the Morgan and the Scott Sociable may be cited. For low powers the two-stroke engine is favoured, but in the medium and higher-powered units the four-stroke engine finds almost universal application. The Scott is, of course, an exception and one of considerable interest, for it has a twin-cylinder two-stroke engine. The Ricardo engine has been applied to the motor cycle with conspicuous success, and the sleeve-valve engine of Messrs. Barr and Stroud, Limited, because of its established reputation for reliability as well as silence, finds extended application to many types and makes of machines. The novel feature of welded steel construction introduced by Messrs. F. E. Baker, Limited, gives a frame of unusual strength and many examples of the machines to which it is applied are to be seen on their stand. Tubes and pressings are united by the welding process to form the frame and petrol tank, while many interesting constructions suited to the various parts of the machine and to the method of joining them together are to be seen in other parts of the cycles.

The Rover cycle illustrated in Fig. 1 and a larger view of the engine with its fittings and the chain drive to the gear shown in Fig. 2 is a 2·5 h.p. machine and the only one which the Rover Company now produce. They have wisely determined to devote themselves to the production of one machine of merit at a low cost rather than have a range of many, which commonly in the motor-cycle trade means the manufacture of machines of very varied reputations. The engine of this cycle is of 250 cub. cm. capacity. It has overhead valves operated through rockers mounted on roller bearings, and both valves are worked from the one cam. The gear-box is a complete unit, which is enclosed in the main crank-case casting and may be expeditiously removed at any time. The chain drive from the crankshaft to the gear is carried round the magneto sprocket, the height of which can be altered by raising or lowering the magneto. In that way chain adjustment is very easy to make. An oscillating type of oil pump driven by an eccentric behind the sprocket is used to force the lubricant through the engine, after which it drains back into the sump and is filtered before recommencing the circuit.

One of the most conspicuous machines in the show is the 3½-h.p. Triumph Fast Roadster, the engine of which was designed in association with Mr. Ricardo and incorporates his many improvements in high-speed petrol motors. It has a single cylinder of 81 mm. bore and 97 mm. stroke, and is fitted with four valves, two for admission and two for exhaust. These are situated on a detachable head, and are actuated by overhead rockers mounted in dustproof roller bearings. As the seats of the inlet valves are recessed into the head the first part of the opening and the last part of the closing motion are practically ineffective. By this means the cams may be formed to give easy and quiet closing and opening combined with a very sharp effective opening. A Ricardo slipper type of piston made of aluminium is fitted. The cycle has the many constructional features characteristic of the firm's productions, and a general view of it is given in Fig. 3, above. It has a three-speed gear and a multiple plate type of clutch. The frame is well sprung and the centre of gravity has been kept low to suit the class of service for which the machine has been designed.

The Ner-a-car shows something of a departure from conventional motor-cycle design. The aim of the designer has been to produce a cycle with completely enclosed mechanism and thus remove the possibility of oil and dirt being thrown upon the

"NER-A-CAR" MOTOR CYCLE AT THE OLYMPIA SHOW.

CONSTRUCTED BY THE SHEFFIELD SIMPLEX COMPANY, KINGSTON-ON-THAMES.

Fig. 4.

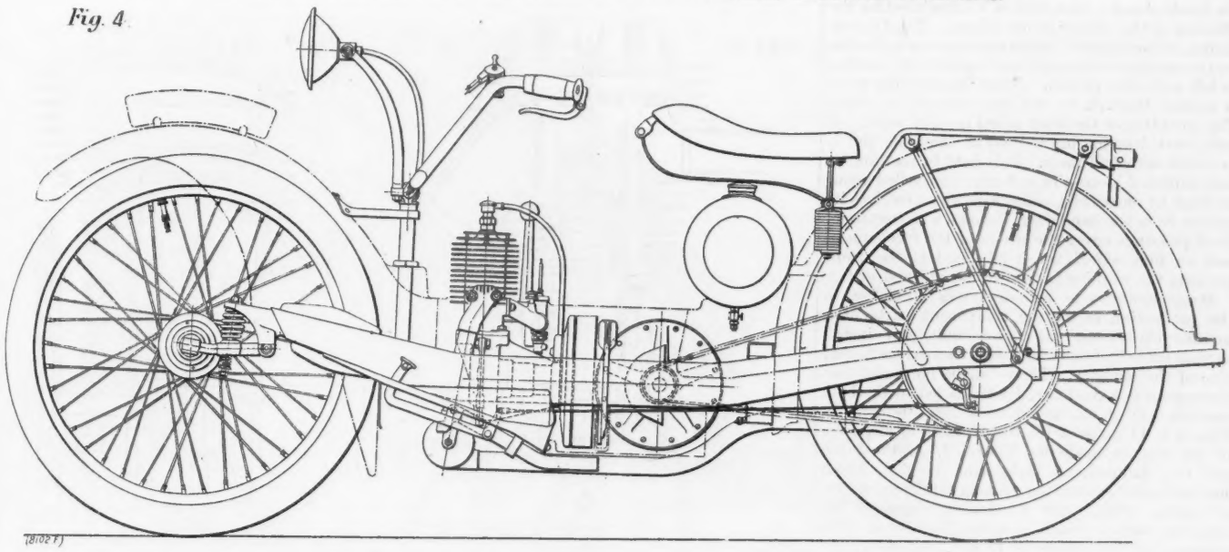
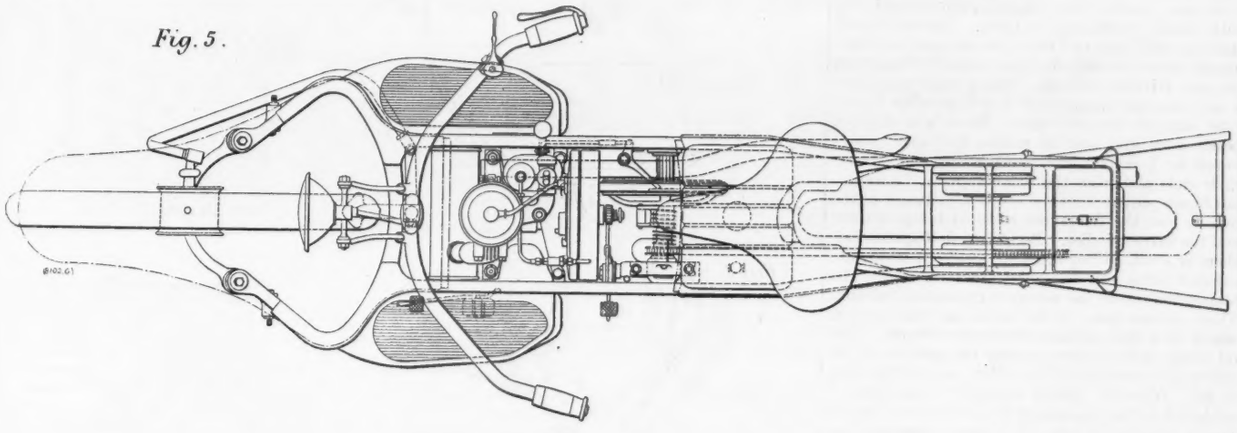


Fig. 5.



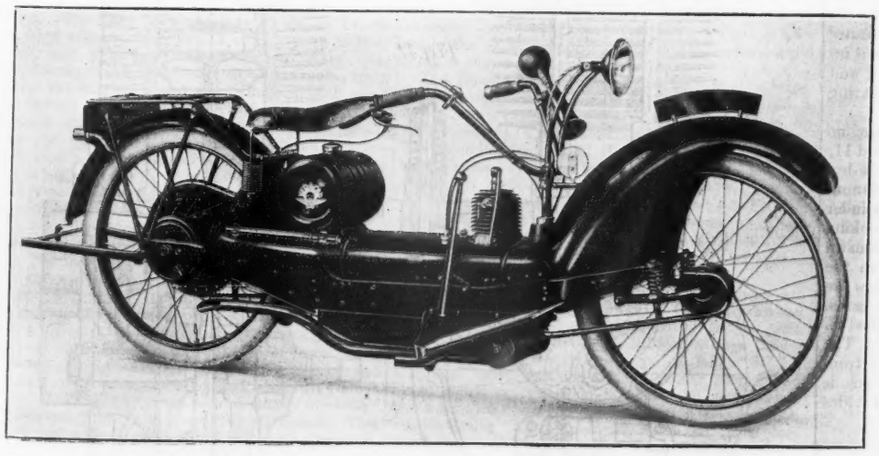


FIG. 6.

FIG. 7.

clothes of the driver. While that intention was kept in mind, the cycle was built with a very low centre of gravity to ensure easy running and stability under all conditions. The machine, of which a plan, an elevation and general views are given in Figs. 4 to 7, is manufactured by the Sheffield Simplex Company, in their works at Kingston-on-Thames. The chassis is built up of pressed steel members of deep channel section reinforced by two substantial cross-members, the front one of which is a pressed steel channel, while the back one is of tubular form. The brackets for the front axle are riveted to the frame, and a substantial construction is adopted at the rear to carry the back axle and the brake gear. The engine, of 70-mm. bore and 74-mm. stroke, is mounted by means of crank-case lugs across the frame, as is the common practice with motor-car engines. The motion is transmitted by friction from

a renewable disc of phosphor bronze on the flywheel to an aluminium wheel provided with a fibre ring on its edge. To obtain a change of gear ratio the wheel is made to move on its shaft towards the centre of the flywheel and a lever system is introduced for the effecting of this change in five stages. This friction system of transmission serves also as a clutch, for the two components may be pressed against one another or left quite free at will. From the shaft the drive is carried through to the back hub by a chain. The mounting of the front wheel is quite novel. A solid steel drop-forging is used as the axle, and is provided with ball races. It is held in position by case-hardened hinge-pins and can be swivelled about on these by means of a radius arm which receives its motion from the handlebars through a lever system. Steel pressings cover the whole of the mechanism, and an undershield which is closed at the front protects the working system from mud and grit.

Many motor-cycle manufacturers specialise in the production of all the component parts of a motor-cycle except the power unit and install engines made by firms who devote themselves to that side of the industry. There can be no doubt that the system is a good one, for it has led to the bulk manufacture of engines of very good design. In Figs. 8 to 11 we show the construction of examples of the engines made by Messrs. J. A. Prestwich and Co., Limited, of Tottenham, London, which find extended application on many different makes of cycles. Figs. 8 and 9 show an engine of 350 cub. cm. capacity with side-by-side valves. The diameter of the cylinder is 70 mm. and the stroke is 90 mm. As the drawings show, the design is one with many interesting features. The half-speed shaft on which the two cams are mounted is immediately above the end of the crankshaft from which the gear drive is obtained. This arrangement gives a very compact design, and makes possible a very rigid support for the cams. These are situated beside each other and the motion they give is conveyed by L-shaped levers which work on pins at their ends and raise the valve tappets. Arrangements are provided for the screw adjustment of the rods to suit the clearances required between them and the valve spindles. Beside the half-speed shaft there is a valve lifter fitted by means of which the exhaust valve can be raised from its seat. The lubrication system has also some interesting features. There are two holes in the crank-case wall through which oil is thrown as the flywheel revolves. This oil settles in the timing case and the position of the outlet pipe ensures that the pinion runs continuously in oil. Whatever passes through to the sump is subjected to the pressure of the air displaced by the piston into the oil box. It is passed through four small disc valves, two of which are shown in Fig. 8, and is deposited at the bottom of the sump. As the piston rises and this oil is subjected to a pressure lower than that of the atmosphere, it is drawn up through a pipe from the bottom of the well and continues its passage through the main bearing and channels to the big end.

The 350 cub. cm. overhead valve type of engine which is illustrated in the drawings Figs. 10 and 11, has slightly different dimensions from the side-by-side type. The bore is 74 mm. and the stroke is 80 mm. The valves work on inclined faces in the cylinder heads and are operated by tubular rods and rocking levers, the motion for which being obtained from an arrangement differing somewhat from that in the other model in the respect that the valve levers are much shorter and are centred just above the cams. The same lubrication system as that described in connection with the other engine is installed. The magneto is mounted on a bracket supported from the crank-case and is driven by a chain which is totally enclosed in an aluminium case which provides an oil bath.

J.A.P. MOTOR CYCLE ENGINES AT OLYMPIA.

CONSTRUCTED BY MESSRS. J. A. PRESTWICH AND CO., LIMITED, LONDON.

Fig. 8.

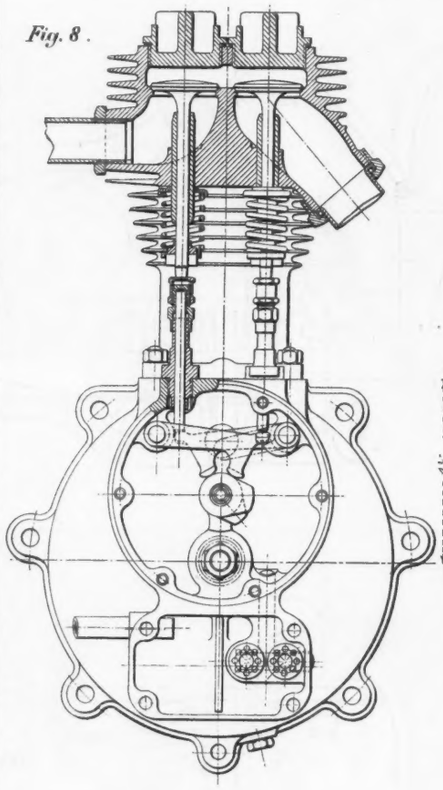


Fig. 9.

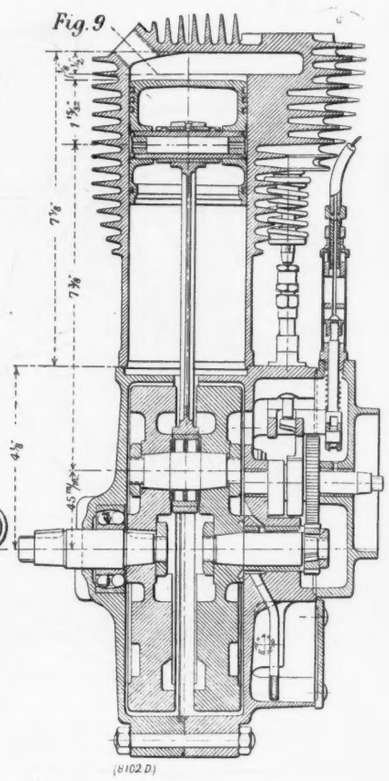


Fig. 10.

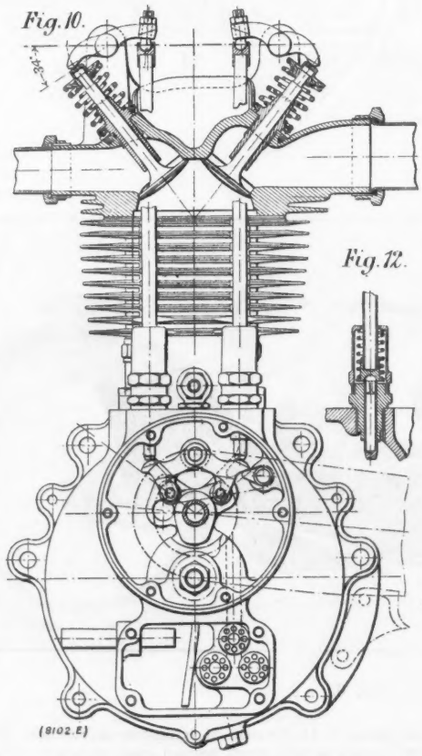
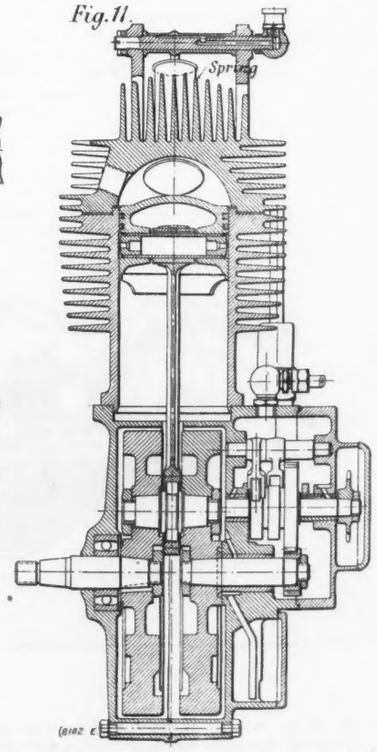


Fig. 12.

Fig. 11.



Chadwick Public Lectures.—Eight public lectures have been arranged by the Chadwick Trust to be delivered before Christmas. The first is to be given on Monday, October 29. These lectures are delivered at various places in London, while two are arranged to be given at the University, Bristol. The subject for the latter is the disinfection of ships. The London lectures are mainly devoted this year to housing and architecture. Further particulars of these lectures which are free, may be obtained from the Secretary of the Chadwick Trust, 13, Great George-street, S.W. 1.

British Iron and Steel Production.—The National Federation of Iron and Steel Manufacturers reports that the production of pig-iron in September amounted to 558,600 tons, compared with 599,800 tons in August and 430,300 tons in September, 1922; the furnaces in blast at the end of the month numbered 190, a further decrease of 6 during the month and a decline of 33 since the end of May. The output of steel ingots and castings amounted to 695,100 tons, compared with 567,500 tons in August and 555,900 tons in September, 1922.

THE DANISH STATE RAILWAY STEAM FERRY "DANMARK."

CONSTRUCTED BY THE ELSINORE IRON SHIPBUILDING COMPANY, ELSINORE, DENMARK.

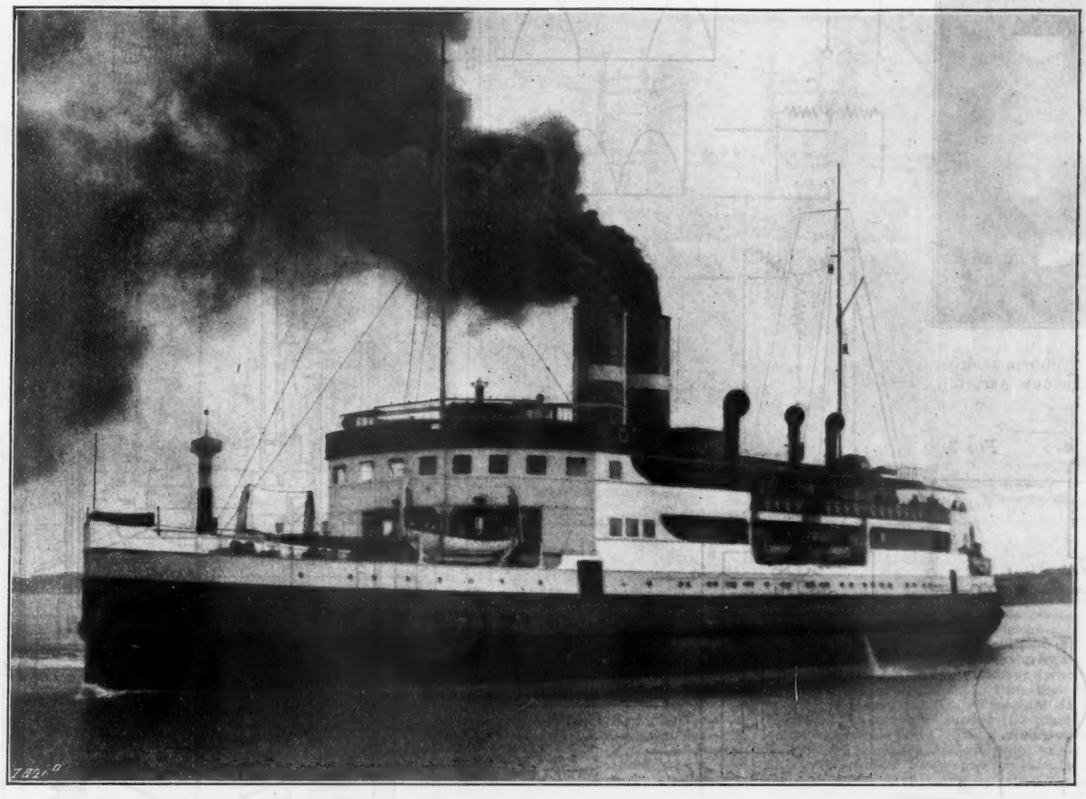


FIG. 7. THE "DANMARK" ON HER TRIALS.

OWING to the geographical conditions of the country, with its many islands and waterways, Denmark early took to the use of steam railway ferries, and the Danish State Railways have always maintained their lead in this branch of locomotion, at least as far as Europe is concerned.

The first Danish State steam ferry began operations on March 18, 1872, when a service was established across the Little Belt, between the island of Fünen and Jutland. The ferry boat was only 43 m., or 141 ft. long, large enough, however, to convey both railway wagons and passengers. Some eleven years were allowed to lapse before the next move was made, when a ferry was started across the Liimfiord, with small boats having one pair of rails. The same year (1883) witnessed the establishment of steam ferry traffic across the Great Belt. These ferries were larger—249 ft. length—with two sets of rails and an aggregate track length of 436 ft. The following year another inland steam ferry connection was set up between Masnedö and Orehoved, and in 1889 a second Liimfiord steam ferry line was opened; the boats used on both of these had only one set of railway lines.

The first international steam ferry dates from 1892, and connected Elsinore (Denmark) with Helsingborg (Sweden), and was followed, in 1895, by the Copenhagen-Malmö (Sweden) system, worked by one Danish and one Swedish boat, each of which was provided with two lines of rails. In 1903, steam ferry traffic across the Baltic, between Giedser (Denmark) and Warnemünde (Germany) was opened with two Danish and two German vessels and became a very important link between Scandinavia and the Continent. This was the last scheme put into operation by Denmark, but plans have been prepared for a steam ferry service between Kallundborg in Zealand and Aarhus in Jutland across the Kattegat, and a great deal of the preliminary work has been done both in Denmark and Norway relating to the contemplated ferry connection between the two countries. Denmark has some two dozen State steam ferries, and the international services have proved useful in advancing commercial intercourse. The traffic on the Danish ferries has been constantly increasing; the number of passengers carried in the course of a year is about 1,000,000, and the quantity of goods transported more than 1,000,000 tons.

The Elsinore Iron Shipbuilding Company, of Elsinore, Denmark, who built many of the earlier ferries, have recently completed the Danmark for service on the Giedser-Warnemünde route. This ship represents the present-day practice of the Danish constructors in the design of this class of vessel and is illustrated by elevation and deck plans in Figs. 1 to 6, Plate XXV; while the general appearance of the completed train ferry is shown in Fig. 7, above.

The Danmark's dimensions are considerably larger than those of the older ferries. The length overall is 333 ft., the greatest breadth is 61 ft., the breadth of the main deck is 51 ft., and breadth on the water line is 50 ft. The moulded depth is 23 ft., and the mean draught, with 500 tons of wagon load and 150 tons bunker coal amounts to 13 ft. 9 in.

The engines are triple expansion, placed side by side, with an aggregate capacity of about 3,500 i.h.p. There are four boilers, each having three furnaces. The aggregate length of the track is 466 ft. The stipulated speed is 15½ knots.

In the accommodation for passengers, there are several important improvements. The older ferries had only a smoke room and a general saloon on the top deck, whilst the Danmark has, in addition, a large dining saloon which can seat 118 persons. A ladies' saloon, a general saloon for non-smokers, toilet rooms, and cloak rooms are provided for first and second-class passengers, for whom this accommodation is common on Danish boats. The passengers can avail themselves of all these saloons, from which there is an unhindered view of the surroundings, without having to pass into the open. A closed staircase leads to the main deck of the ferry, where there are large general saloons for ladies and gentlemen and a dozen private cabins, each for two persons. The two promenade decks for the first and second, and for third class are protected by roofs and large windows amidships, so that there is always shelter against wind and rain. The third-class passengers have also been well provided for. On the upper deck there is a smoke room for third-class passengers and on a main deck a large dining and general saloon, with separate ladies saloon.

By means of the large ballast tank installations the ferry can be balanced in different ways, according to the prevailing conditions. The doors in the watertight bulkheads can be closed from the bridge and all sections of the vessel have staircases to the main deck, so that there is no fear of anyone being trapped. The Danmark shows many improvements, both in regard to the design of the vessel and the engines compared with the earlier steam ferries. The life-saving appliances appear to be adequate; there are four whaleboats, each giving accommodation for 25 persons and four lifeboats, each of which was designed for 32 persons, making provision for 228 persons in all, for whom there is an ample supply of lifebelts.

CONVERSION FROM ALTERNATING TO DIRECT CURRENT BY MEANS OF MERCURY-ARC RECTIFIERS.*

By R. L. MORRISON, A.M.I.E.E.

IN this country the form of electrical supply generally available for the lighting consumer is direct current. The same system is in use for our tramway services, while the recent decisions in connection with our main line electrification schemes are in favour of this form of supply. It is usually admitted to be the system most suited to all round conditions—it is a matter open to much controversy but the concensus of opinion leans in the direction indicated. For economic reasons generation and distribution to converting sub-stations at high alternating current pressures is essential. Conversion from alternating to direct current, up till quite recently, has been by means of rotating converters of one form or another. These all possess the inherent disadvantages of rotating machinery, and the object of the development briefly described in this paper is the elimination of these disadvantages, and thereby to provide a plant that can be compared in simplicity to the ordinary static transformer.

The high power mercury-arc rectifier is probably one

* A paper read before Section G of the British Association at Liverpool, September 19, 1923.

MERCURY ARC RECTIFIERS.

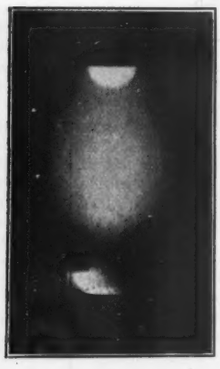


Fig. 1. Photograph of Mercury Arc.

Fig. 2.

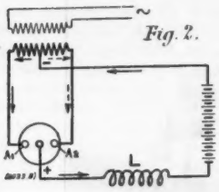


Fig. 4.

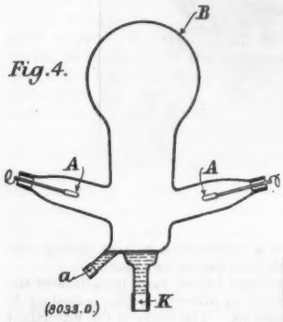


Fig. 5.

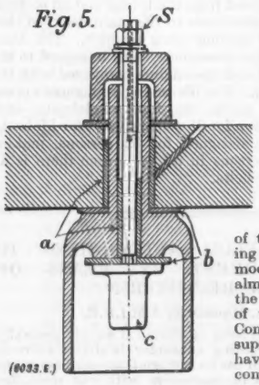


Fig. 3.

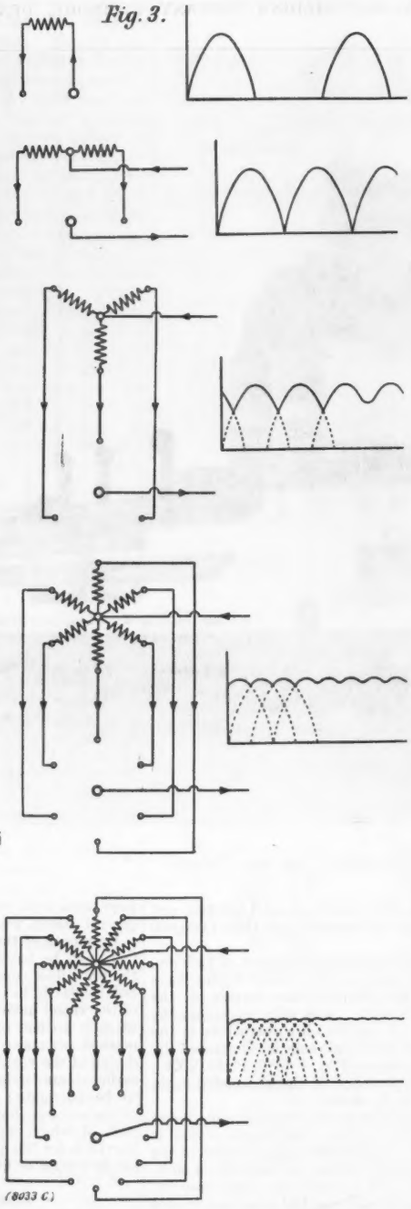


Fig. 6.

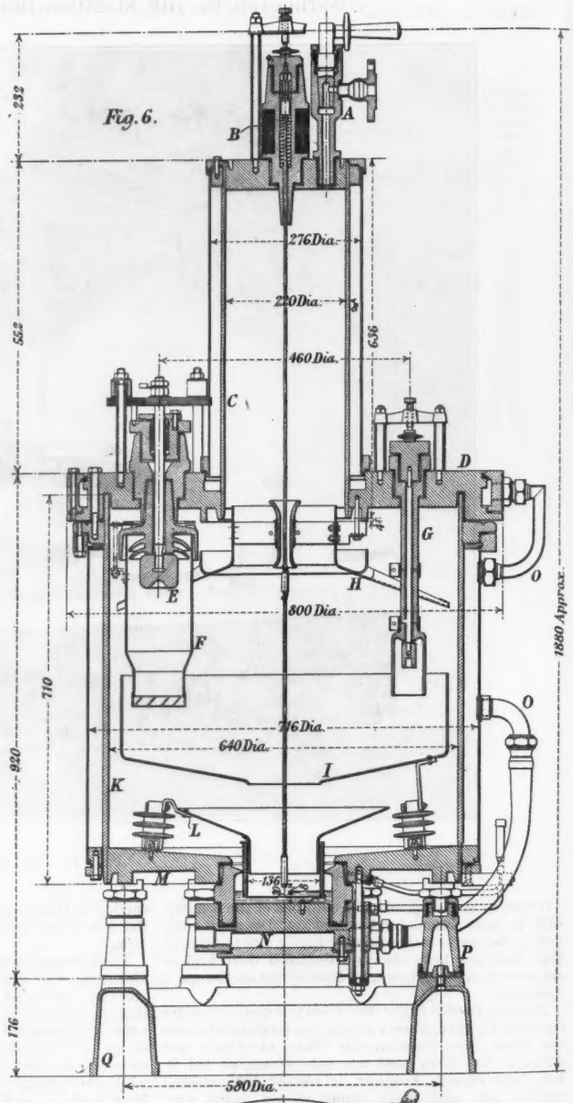


Fig. 6a.

of the most outstanding developments of modern times and is almost entirely due to the persistent efforts of the Brown, Boveri Company. Almost insuperable difficulties have had to be overcome, and in consequence the advance to the present satisfactory position has been somewhat slow, though when it is appreciated that these difficulties had reference to physical phenomena about which very little was known, the progress made is really amazing, and with continued experience we can look forward with complete confidence to the production at no distant date of stationary plant for conversion from alternating to direct current equal in reliability to the static transformer.

For high tension direct-current electrification the rectifier stands out pre-eminently as the ideal converter because of the ease with which the pressures employed can be handled, while, in addition, the overall efficiency in such circumstances is considerably higher than that obtainable with any other known type of converter. The saving effected by the use of rectifiers for these conditions is very considerable, not only because of the better efficiency but also due to the low maintenance and attendance charges pertaining to this class of plant.

Valve Action of the Mercury Arc.—It is some twenty years since Mr. Cooper-Hewitt noticed that the mercury arc when operating in high vacua had the peculiar property of permitting the passage of a current in one direction only. In other words, the current is intercepted at each half period, the positive half waves only passing between the two opposing electrodes. The arrangement thus constitutes an electric valve. An explanation for this valve action can be given by assuming that the cathode surface which is raised to a state of incandescence at the point where the arc strikes it (known as the "cathode spot") is conducting to electrons in both directions, while the cooler electrode, the anode, conducts only in one direction. From this it is seen that the valve action is almost entirely due to the anode. The arc takes the form of a luminous column spreading like a halo over the whole surface of the anode and centreing in one spot at the cathode, which spot travels at high speed in irregular paths over the surface of the mercury. This rectifying effect is not the peculiar property of mercury but is simply due to the arrangement of two electrodes whereby one (the cathode) is raised to a high temperature (about 3,000 deg. C.) and the other (the anode) is maintained at a temperature (400 deg. C. to 600 deg. C.) below that at which the formation of electrons is possible. In the rectifier, mercury is used because its

MERCURY ARC RECTIFIERS.

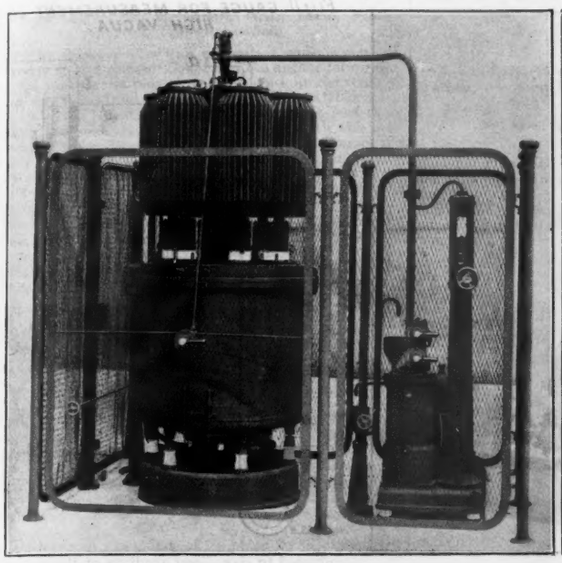


Fig. 7. Low Tension Rectifier.

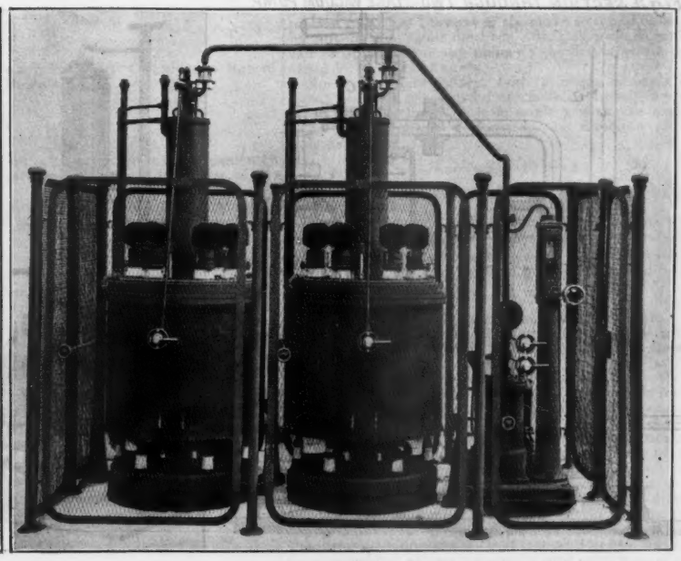


Fig. 8. High Tension Rectifiers.

vapour can be easily condensed and led back to the cathode without loss.

In Fig. 1 we have a photograph of a mercury arc with the anode at the top and the cathode in the cup at the bottom. The arc, as will be seen, is in the form of a halo spread evenly over the surface of the anode while, at the cathode, it centres in the "cathode spot." The intervening space is largely occupied by a spongy-looking luminous column which extends down from the anode about three parts of the way and then stops abruptly, leaving a dark space.

Single and Poly-phase Rectifiers.—It has been shown that the arc only deals with the positive half of the alternating wave. To make the arrangement commercially possible both halves must be utilised, and this is obtained by connecting in the manner shown in Fig. 2, which represents a single-phase two-anode rectifier with step-down transformer having a divided secondary, the mid point of which is brought out and forms the negative pole of the direct current system, the cathode forming the positive pole. Considering first the positive half wave, this induces a current in the left half winding flowing towards anode A_1. During this half period the right half winding is inactive but at a potential equivalent to that of the left half winding, only of opposite polarity. No current is flowing in this winding due to the valve action of the arc. As the wave passes through zero, the negative half comes into play in the right half winding inducing a current flowing towards anode A_2. The left half winding is now inactive but at an opposite potential equivalent to that of the other half. With each cycle this process is continued and both half waves are completely utilised. As it requires only a cessation of the current for a very small fraction of a second to cool the cathode spot sufficiently to extinguish the arc, reactance is inserted in the rectified circuit at L, thus prolonging the wave and preventing it dropping to zero. By making the reactance large enough it is possible so to reduce the undulations in the rectified wave that even a single-phase primary supply can be satisfactorily converted and commercially used. The best results are, however, obtained where the primary supply is three-phase, and in Fig. 3 is shown the improvement that is effected by increasing the number of phases. At the points of intersection of each wave the arc passes from anode to anode and takes the form of a cone with its apex centred in the cathode—there is therefore a separate pulsation for each anode, so that the periodicity of the pulsations is the frequency of the incoming supply multiplied by the number of anodes. The connection in general use is the six-phase because it gives almost a straight line wave—it also simplifies the design of the rectifier and the transformer.

At this point it might be mentioned that the k.v.a. rating of rectifier transformers is always greater than the direct current output of the rectifier and is accounted for by the r.m.s. value of the phase current being very high as compared with the average value, thus necessitating heavier secondary windings than in the normal case. For the single-phase rectifier this increase in size amounts to 50 to 100 per cent., for the six-phase 55 per cent., for the twelve-phase 84 per cent., and for the eighteen-phase 112 per cent. These indications show that it is unwise to increase the number of phases beyond a certain limit and for all practical conditions this limit is six. From what has been said in the foregoing it is clear that the transformers are of special design, and, apart altogether from stepping down from the high tension pressure to one to suit the rectifier, that an ordinary standard transformer would be unsuitable.

The Construction of Rectifiers.—The glass bulb Cooper-Hewitt pattern shown in Fig. 4 is well known to most people. It supplies the demand for converters of small output and consists of a highly exhausted bulb (B) where the mercury vapour condenses, a mercury cathode (K), an auxiliary ignition anode (*a*) and several projecting anode tubes corresponding to the number of phases of the supply to be converted. To start the arc the arrangement is tilted so that the mercury runs from the cathode to the ignition anode (*a*). Current immediately flows between these two points and on the vessel being tilted back an arc is started at the point of rupture. This starts the main arc between the anode tubes and the cathode. Glass bulb rectifiers are manufactured to deal with outputs up to about 50 kw. and where larger outputs are required the units can be multiplied. They are used principally for battery charging, cinematograph work, &c., though latterly their use has been extended to conditions where larger amounts of power are required. Though limited in scope, they serve a very useful purpose and can be regarded as the pioneer of the larger plant described hereafter—in fact, it was the ease with which the former could be operated that led to the conception of the latter.

For the successful operation of the rectifier high vacua are essential, the normal working range being 0·01 to 0·001 mm. Hg. The first problem therefore that had to be tackled in the manufacture of the high-power mercury-arc rectifier was the production of large steel cylinders that would be at once accessible and gas-tight. The mercury seal was finally adopted as giving the best results. It consists of mercury and asbestos for the hotter portions, and mercury and rubber for the cooler parts. This seal is very efficient and vacua such as have been referred to can easily be maintained. The arrangement is shown diagrammatically in Fig. 5—the mercury is at *a* and the asbestos at *b*. As a sealing medium mercury has the advantage that should any filter inwards it can only find its way to the cathode and will not interfere in any way with the operation of the plant.

The one really serious difficulty, however, that for a long time baffled all attempts to overcome it was that of internal flashing-over, or "back-firing" as it is sometimes termed. From what was said earlier it will have been gathered that to make the valve action possible the electrodes must operate at certain temperatures relative to each other and, if for any reason one of the iron electrodes becomes hot enough to start electronic emission, the valve effect would cease and the current would flow in both directions between it and the opposing anode, this constituting an internal flash-over. Such occurrences may also be due to other minor causes which, however, are not now of sufficient importance to be mentioned. The more usual cause is unsuitable material, whereby gases are suddenly liberated and temporarily destroy the vacuum on a portion of the anode surface, producing local overheating. A noteworthy feature is that serious harm is rarely done by an internal short-circuit which as a rule only calls for the opening up of the rectifier and either changing or re-polishing the affected anode. For a long time this question has been receiving the closest attention from those on the development side, and as a result of the latest researches it can be definitely stated that the trouble has been practically overcome by the use of more suitable anode material.

A Brown-Boveri rectifier of recent design is shown in Fig. 6. The major portion is the large welded steel cylinder (K) in which the arc operates and above it the narrower condensing cylinder (C). These two cylinders are connected by the heavy anode plate (D) while the lower portion of the arc chamber is closed in by the plate (M) in the centre of which the cathode is located. The condensing cylinder is closed at its top by a plate carrying the ignition coil (B). The rectifier, as a whole, is mounted on the insulators (P), these in their turn being carried on the foundation ring (Q). There are six main anodes (E) and two auxiliary anodes (G) placed in a circle around the anode plate. The auxiliary anodes serve to maintain the arc when the load drops to a very low level (about 40 amps.). They may be said to constitute a single-phase rectifier within a six-phase one, because they are connected externally with a small exciting transformer providing about ½ k.v.a. which keeps up the temperature of the cathode spot. The mid-point of the exciting transformer is brought out as in the case of the main transformer and connected through a resistance and small reactance to the cathode—the former limits the current consumed while the latter ensures that the auxiliary arc will not drop to zero at each half period.

The main anodes are screwed to the anode bolts which convey the current to them—the transformer connections are brought to lugs fitted to the upper part of these bolts. Specially designed insulators separate the anodes from the anode plate. The arc guides (F) are fixed to the main insulators and, at their open ends, terminate in the large collecting funnel (I) while immediately above the cathode there is a smaller funnel (L). The arc works between the main anodes (E) and the cathode; it has a well-defined path which diminishes the risk of flashing-over. At the point of contact of the arc with the mercury, a dense cloud of vapour is given off. The un-ionised portion of this vapour rises between the anodes and finds its way into the condensing cylinder where a reduction in temperature takes place due to the water jacketting, and it is re-condensed and drops back in the form of drops into the collector (H). From here it runs down the sloping troughs to the sides of the arc chamber and thence back to the cathode, so that there is no loss and the mercury need never be replenished.

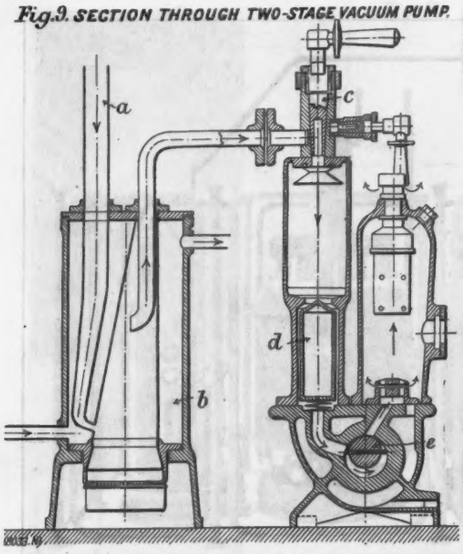
For cooling purposes a small quantity of fairly good water is necessary, that usually obtainable from the town mains being suitable. It first passes through the cathode base (N), from there to the jacketting round the large cylinder and the anode plate by the connections (O), after which it passes to the jacket surrounding the condensing cylinder and then out to waste or a separate re-cooling system. For the ignition of the arc a push-button switch operates the solenoid (B) at the top of the condensing cylinder and the long rod passing down the centre of the rectifier. This rod has at its end a small anode poised just above the mercury. The cock (A) connects the rectifier with the vacuum pump.

It might be mentioned here that, as far as the rectifier proper and vacuum pump are concerned, it is essential that the materials used in their construction should be the best procurable. Extremely fine limits are worked to and the whole assembly is a piece of work requiring the very highest class of workmanship.

The low-tension rectifiers are made in three sizes to deal with roughly 300, 600 and 1,000 amps., at pressures up to about 600 volts. For higher direct-current pressures that may still be considered on the lower scale, namely, up to, say, 800 volts, the current ratings may vary slightly. Two high tension rectifiers are also manufactured, the first for pressures up to 3,000 volts and the second to 5,000 volts, the current rating, in each case, varying from about 250 to 750 amps., according to

MERCURY ARC RECTIFIERS.

Fig. 9. SECTION THROUGH TWO-STAGE VACUUM PUMP.



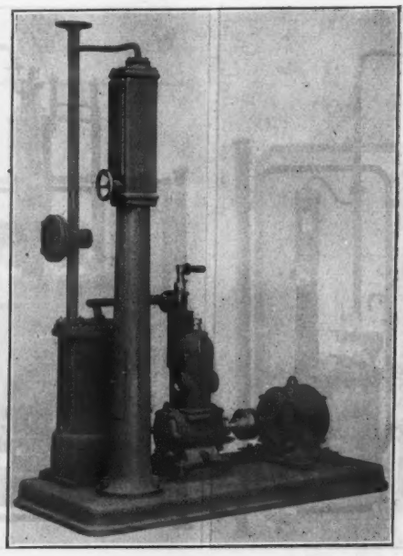


Fig. 11. GAUGE FOR MEASUREMENT OF HIGH VACUA.

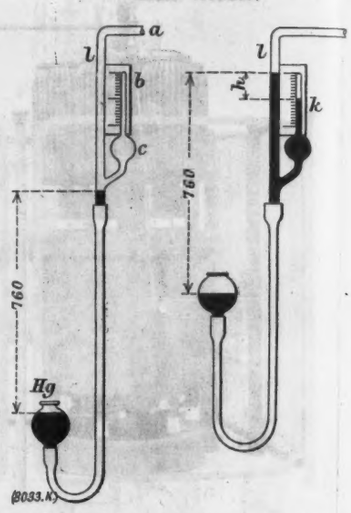


FIG. 10. VACUUM PUMP SET.

the pressure. A low tension rectifier for dealing with 1,000 amps. is shown in Fig. 7. It will be noticed that there is one essential difference as compared with the small rectifier shown previously in section, namely that the larger ones have anode radiator coolers in which the water circulates on the thermo-syphon principle. The H.T. types have short stumpy cooling fins for the anodes, as seen in Fig. 8. This is a photograph of one of the sixteen 1,200-kw. 1,575-volt plants manufactured for the Midi Railway of France. It will, of course, be understood when speaking of rectifiers dealing with 5,000 volts direct current that this is accomplished in a single unit. Where larger amounts of power require to be handled than is represented by single cylinders it is customary to place two or three in parallel with a single main transformer. The ideal arrangement is to have a separate transformer for each cylinder, but this naturally involves a heavier initial outlay.

Auxiliaries.—In its present state of development it is impossible to do away with certain auxiliaries which will be briefly referred to.

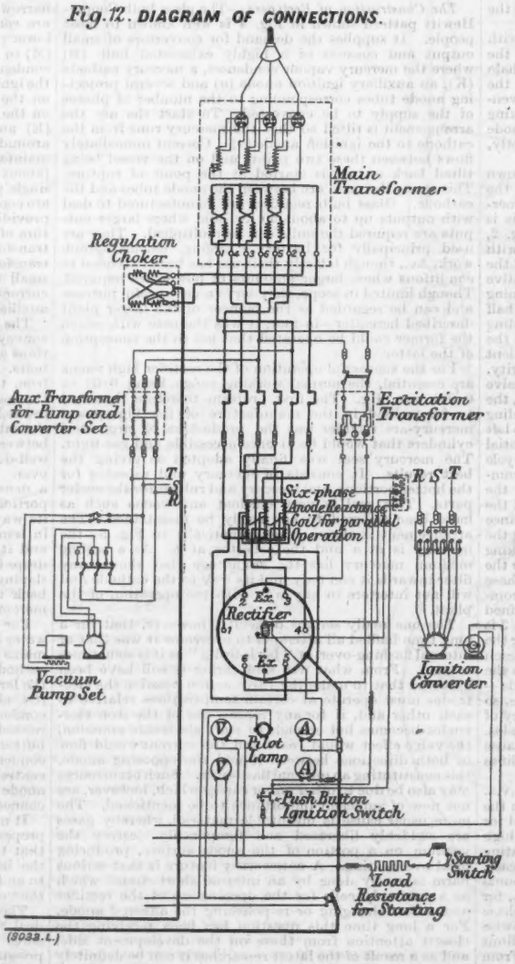
The first in importance is the vacuum pump set because a high vacuum is absolutely essential to the satisfactory operation of the rectifier. The pump used is of special design and extremely efficient. It consists of a high vacuum mercury pump in series with a rotary oil-immersed pump, Fig. 9. The latter pump is direct coupled to a ½-h.p. motor and is capable of creating a vacuum equivalent to about 0·02 mm. Hg., the final reduction to 0·001 mm. Hg. and below being obtained by means of the mercury pump which is so remarkably efficient that it can extract large quantities of the lightest gases under the normal pressure conditions applicable to rectifiers. This pump has at its base in the chamber *b* a pool of mercury which is heated by an electric heater located immediately below. The operation is very simple: the mercury pump works on the injector principle, this action being produced by the vapours rising from the boiling mercury and in doing so sucking the air and gases down the pipe *a*, connected to the upper portion of the rectifier cylinder. The conical section of the mercury pump is water jacketted so that, as the mixture of vapour and gas rises, the vapour is re-condensed and drops back into the pool at the bottom, while the gas is drawn off by the rotary pump as indicated by the arrows and then discharged to atmosphere. The rotary pump has a non-return valve *d* which operates in the event of the pump shutting down and thus prevents the oil and air finding its way into the stationary pump and rectifier. The complete pump set, as shown in Fig. 10, is mounted on a common base plate standing on a number of insulators, which insulate it from earth, this precaution being necessary on account of it being connected through the vacuum piping with the rectifier proper which is statically charged.

The type of vacuum gauge used is known as McLeod's, the principle of which is based on Boyle's Law $pv = c$. It is shown diagrammatically in Fig. 11. On the left-hand side we have the arrangement when not in use showing the measuring bulb *c* free to fill with the mixture of air and gas from the rectifier through the tube *a*. When it is desired to obtain a reading, the bulb "Hg" is drawn upwards by suitable mechanism and the mixture in the bulb is forced into the capillary tube *k* by the rising mercury. When the mercury in the tube *l* is level with the top of the capillary tube there is a difference of level *h* between the two columns, which is a measure of the pressure in the rectifier. The arrangement is such that very small differences of pressure can be ascertained, while the scale can be graduated to give direct readings of the vacuum by the use of the equation

$$V p_x = vh \text{ or } p_x = \frac{v}{V} \times h,$$

where V is the known volume of gas in the measuring bulb, p_x the unknown pressure and v the volume in the capillary tube when compressed.

Fig. 12. DIAGRAM OF CONNECTIONS.



Next in order we have the ignition converter which provides an independent source of current to start the arc. It consists of a ¼-kw. motor generator set which is only run for a few seconds when required. The starting up of a rectifier is an extremely simple matter and certainly considerably more so than with any other class of converter. It used to be thought that the anodes should be heated up prior to the rectifier being put on load, but it has been proved that once the rectifier is properly formed this precaution is unnecessary and it can be switched on to the bus-bars immediately the arc has been struck. Consequently, as synchronising has not to be considered, such a plant can be put into commission from standstill within a few seconds, this including all switching operations. A push-button switch controls the ignition circuit, which is so arranged that, on the switch being depressed, the solenoid connected to the ignition anode (which latter is normally poised immediately above the mercury cathode) is pulled down and the anode comes into contact with the mercury. When this occurs the solenoid is short-circuited and the ignition anode is drawn up again by a spring acting in opposition to the pull of the solenoid. At the point of separation an arc is started and if there is pressure on the main anodes they immediately come into action and the rectifier is ready for duty.

Another auxiliary of importance is the absorption or regulation reactance coil placed in the neutral point of the main transformer, its function being to limit the inherent regulation of the complete plant to a reasonable figure—usually of the order of 5 per cent. from full to approximately no load. Without this coil in use the regulation may be as high as 10 to 12 per cent. In the diagram Fig. 12 the transformer secondary is seen to be arranged as two three-phase star connected groups, the two neutral points being brought out to the absorption coil. This coil has a duplicate set of windings, with a common magnetic circuit, which act in opposition and produce a powerful throttling effect, causing the phase currents to overlap so that at least two phases are made to function simultaneously. Consequently the r.m.s. value of the phase current is reduced and a slightly smaller transformer can be utilised. It is also obvious that if the r.m.s phase current is reduced, the overall drop which is proportional to the current must decrease as well, resulting in the above figure of about 5 per cent. from full load to very small loads.

(To be continued.)

MINING CONCESSIONS IN ALGERIA.—H.M. Consul-General at Algiers has received an inquiry for the names and addresses of British firms interested in the purchase and exploitation of mines in Algeria. The inquiry indicates the existence of a calamine deposit with exploratory workings, in addition to deposits of lead, radioactive mineral, silver and phosphate containing 60 per cent. of phosphate of lime. A geographical and descriptive report (in French), with analysis, can be seen by interested British firms on application to the Department of Overseas Trade.

ON THE GRAPHICAL DETERMINATION OF STRESS FROM PHOTO-ELASTIC OBSERVATIONS.*

By Professor L. N. G. FILON, M.A., D.Sc., F.R.S., University College, London.

IN the 1914 report of this committee various methods were given by Professor Coker and the author for obtaining the stresses in a plate of transparent material strained in its own plane from the "isochromatic" and "isoclinic" lines. (B.A. Report, 1914, pp. 201–210.) It was there shown that the isoclinic lines, together with the conditions at the boundary, theoretically determine the stress system completely. Before, however, this determination can be carried out, it is necessary to fit exact functional relations to these isoclinic lines, and this is a very difficult matter in practice.

In the same report a method was given whereby the stresses $\widehat{xx}$, $\widehat{yy}$, $\widehat{xy}$ could be derived from a knowledge of both the isoclinic and the isochromatic lines. If P, Q are the principal stresses at any point and the stress Q makes an angle ϕ with the x axis, then

$$\widehat{xy} = (P - Q) \sin \phi \cos \phi \quad . \quad . \quad (1)$$

and is thus known everywhere.

Step by step integration of the stress equations—

$$\frac{\partial \widehat{xx}}{\partial x} + \frac{\partial \widehat{xy}}{\partial y} = 0, \quad \frac{\partial \widehat{xy}}{\partial x} + \frac{\partial \widehat{yy}}{\partial y} = 0 \quad . \quad (2)$$

along straight lines parallel to the axis then gives $\widehat{xx}$ and $\widehat{yy}$ at every point, if their values (as is usually the case) are known at the boundary. The weakness, however, of this last method in practice is that the observations are never really accurate enough for the differential coefficients $\frac{\partial \widehat{xy}}{\partial x}$, $\frac{\partial \widehat{xy}}{\partial y}$ to be determined with sufficient exactness from the values of $\widehat{xy}$ given by (1), using the observed values of ϕ and P Q. For these reasons neither of the methods given in the report referred to has been employed in practice to obtain the stress-system.

The method at present generally used is one which has been described fully by Professor Coker in various places, in particular in his presidential address to Section G of the British Association in 1914 (Report, p. 495), and which was originally suggested by Mesnager. It consists in obtaining the sum (P + Q) of the average principal stresses in the plane of the plate by measuring the lateral contraction of the plate at the point in question.

This method has given good results, but it is not, from the theoretical standpoint, entirely unexceptionable, for in the calculation it is assumed that the material is perfectly elastic, with a definite Poisson's ratio, which has to be measured by a separate experiment. But as a matter of fact the experiments of Filon and Jessop (Phil Trans. A Vol. 223, pp. 89–125) have shown that celluloid exhibits considerable strain-creep for limits of stress well below those which occur in the large majority of photo-elastic experiments, and this introduces an undesirable element of uncertainty into the results, unless, as in Coker's investigations, the material employed is selected with the greatest care.

Moreover, it should theoretically be possible to deduce the stresses completely from observation of the isoclinic and isochromatic lines alone, and the introduction of a strain measurement really brings in superfluous data, with a possibility of inconsistencies which it may be difficult to trace to their source. Finally, the measurement of such minute lateral contractions is one of extreme delicacy, and very few investigators have at their disposal the necessary apparatus for carrying it out.

For the above reasons it appears of importance to describe in some detail a practical method of deriving the stresses in a transparent plate directly from the isoclinic and isochromatic lines, and to give an actual example of its application. It is believed that this method is free from the defects inherent in the other method of step by step integration, described in the 1914 B.A. Report p. 206, and referred to previously.

The method is based upon equations given by A. Mesnager Annales des Ponts et Chaussées (Partie Technique) 9e série (tome 16, vol. 4, pp. 135–186) for the space-rates of change of the principal stresses, taken along the lines of principal stress.

If we denote by s_1, s_2 arcs taken along the lines of principal stress corresponding to stresses P, Q respectively (Fig. 1), ds_2 being obtained from ds_1 by a counter-clockwise rotation of 90 deg.; and if ρ_1, ρ_2 are the radii of curvature of the two lines of principal stress, being measured positive when the tangents to the curves rotate counter-clockwise as the arcs s_1, s_2 increase, we have the equations:—

$$\frac{\partial P}{\partial s_1} + \frac{P - Q}{\rho_2} = 0 \quad . \quad . \quad (3)$$

$$\frac{\partial Q}{\partial s_2} + \frac{P - Q}{\rho_1} = 0 \quad . \quad . \quad (4)$$

These equations are very readily obtained by considering the equilibrium of a "curved elementary rectangle" bounded by four near lines of principal stress, and expressing the conditions that the total force resolutes parallel to the tangents to the lines of principal stress at one corner A are zero, it being assumed that the plate is under no "body-force."

These equations, it will be noted, are quite independent of stress-strain relations, and hold equally in a plastic and in an elastic solid.

If we start from a point O, where the P stress is P_0, and proceed along the corresponding line of principal stress to any point A, we have, integrating (3)

$$P = P_0 - \int_0^A \frac{P - Q}{\rho_2} \, ds_1 \quad . \quad . \quad (5)$$

And, similarly, if we proceed from O along a line of Q stress to a point B, we have

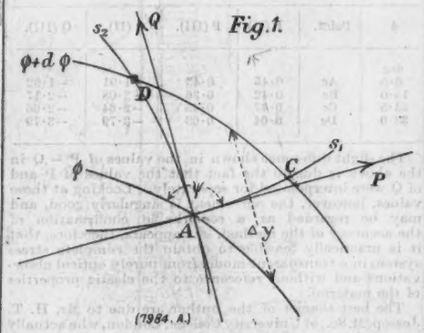
$$Q = Q_0 - \int_0^B \frac{P - Q}{\rho_1} \, ds_2 \quad . \quad . \quad (6)$$

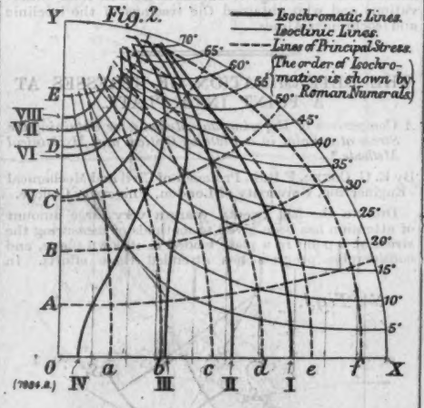
Now there are two ways in which we may conveniently compute the integrals on the right hand sides of (5) and (6).

Call ϕ as before the angle which ds_1 makes with the positive direction of the axis of x. Then

$$\frac{1}{\rho_2} = \frac{\partial \phi}{\partial s_2}$$

Now consider a point A (Fig. 1) through which passes the isoclinic of parameter ϕ and let C D be a near





isoclinic, of parameter $\phi + d\phi$, which meets the line of P stress through A at C and the line of Q stress through A at D. Then

$$\frac{1}{\rho_2} = \frac{d\phi}{AD}$$

and

$$ds_1 = AC \quad \therefore \quad \frac{1}{\rho_2} ds_1 = d\phi \times \frac{AC}{AD}$$

Let ψ be the angle through which the line of P stress has to be rotated (counter-clockwise) in order to bring it upon the isoclinic.

Then, from Fig. 1, $AD/AC = -\tan \psi$, and thus

$$P = P_0 + \int_{\phi_0}^{\phi} (P - Q) \cot \psi \, d\phi \quad . \quad (7)$$

Equation (6) will then take the symmetrical form

$$Q = Q_0 + \int_{\phi_0}^{\phi} (Q - P) \cot \psi' \, d\phi \quad . \quad . \quad (8)$$

where ψ' is the angle through which the line of Q stress has to be rotated to bring it upon the isoclinic.

Now the value of P − Q can be read off at any point from observation of the isochromatic lines, or by direct measurement with a compensator. The values of ψ are obtained from the isoclinics by subtracting, from the inclination to the x-axis of the tangent to the isoclinic, the parameter of the isoclinic itself.

The isoclinics are usually well-defined brushes, of which the *direction*, at any point, can be observed with considerable accuracy. Accordingly ψ should be read off with an error of only 1 or 2 degrees in most cases. It is necessary, of course, to draw the lines of principal stress, since these are the paths of integration. But, given the isoclinic lines, this presents usually no difficulty, and, as a rule this is the most accurate and immediate deduction from the optical data.

Once the lines of principal stress have been drawn, P − Q and ψ should be noted for the various points at which a given line of stress meets the successive isoclinics. The values of $\overline{P - Q} \cot \psi$ can then be calculated and plotted to ϕ, and the area of the curve so found obtained by any of the usual methods. In this way, P and Q can be obtained for any point on the line of stress, provided P_0 (or Q_0) is known.

Now, at the boundary, both principal stresses can be obtained if the applied traction is entirely known. If the P stress line makes an angle χ with the normal n to the boundary, s denoting the direction of the boundary itself, then

$$\widehat{ss} - \widehat{nn} = (Q - P) \cos 2\chi$$

and $\widehat{nn}$, $\widehat{ns}$ being supposed known, $\widehat{ss}$ is given by this equation.

The simplest and most important case occurs when we are dealing with a part of the boundary entirely free from traction. In this case $\widehat{nn} = \widehat{ns} = 0$, the boundary itself is a line of principal stress (say Q stress) and

$$\widehat{ss} = Q - P$$

as given optically; P, of course, being here zero. We may thus follow any one line of principal stress which starts from a free portion of the boundary, and the stresses P, Q are completely known along this line. It may be that procedure thus will allow us to reach directly all the region of the plate which we wish to explore, in which case the problem is solved. If, however, this is not the case, we may now take any point already reached as starting point and proceed from it along the orthogonal line of principal stress. In this way the whole of the plate will ultimately be reached.

The formula (7) becomes highly inaccurate if ψ be small, in which case a slight error in ψ makes a large error in $\cot \psi$; and also the isoclinics being then nearly parallel to the line of principal stress considered, the intervals along the path of integration are too large for the method of quadratures to give accurate results. In this case we have to treat equation (5) by a different method. Let Δy (Fig. 1) be the intercept, measured perpendicular to the path of integration, between two near isoclinics in the neighbourhood of the point considered, whose parameters differ by $\Delta \phi$. Then $1/\rho_2 = \Delta \phi / \Delta y$ approximately. And if we take the interval $\Delta \phi$ constant throughout, which will usually be the case since the isoclinics should be drawn for constant differences of ϕ, we have equation (5) leading to

$$P = P_0 - \Delta \phi \int_0^A \frac{P - Q}{\Delta y} \, ds_1 \quad . \quad . \quad (9)$$

and the integration can be proceeded with graphically as before.

This method is specially useful when, as not infrequently happens in cases of symmetry, there exists a line of principal stress which is straight, and therefore is also an isoclinic. Δy is then the intercept between this line and the nearest (curved) isoclinic, measured perpendicular to the (straight) path of integration.

As an example of the method a small disc of a transparent insulator called *backelite* was placed in a straining frame and compressed along a diameter. The disc carried a network of reference lines and the appearances were projected on a screen, upon which the isoclinics and isochromatics were traced with a pencil. Backelite was selected because its stress-optical coefficient (recently determined as 50 brewsters by Mr. I. Arakawa in a M.Sc. Dissertation of the University of London) is at least five times that of celluloid and therefore, for a given thickness, a far larger number of isochromatic lines is brought into the field. The difficulty with this material is usually that it shows considerable optical effect in the unstrained state, but it was found possible, by a method due to Mr. H. T. Jessop, to obtain almost perfect annealing of this particular specimen.

The disc compressed along a diameter was selected as a type of stress because its mathematical solution is simple and well known. (See Love, Theory of Elasticity, 3rd Edition, Article 155) and would afford a basis for comparison. It was found, however, in practice, that the compressing pieces flattened the disc and the pressure was spread out over a quite considerable arc. The straining frame used did not allow of the total pressure being found directly. The ratio of this to the stress has been deduced from the observations themselves. In like manner it will appear that neither the stress-optical coefficient of the backelite, nor its elastic constants, needed to be determined, and these points are of some importance as they show how, in many cases, the method is largely independent of subsidiary determinations. The isoclinics (drawn for every 5 deg. of ϕ) and the isochromatics, of orders 1 to 8 are shown in Fig. 2, for one quadrant of the disc only, the others being deducible from symmetry. The isoclinics are shown in Fig. 2 by thin lines and the isochromatics by thick ones, the isochromatic of order zero being the boundary itself. The lines of principal stress, drawn from the data supplied by the isoclinics are shown by the dotted lines which should be co-axial circles according to theory. Those surrounding the point Y show a certain amount of ellipticity which agrees with what one would expect if the pressure is spread out on either side of Y.

The first step was to use formula (9) to obtain P and Q along O X, P being here horizontal. The radius r of the circular image was 3¼ in. and measurements were taken in inches. The results, however, are not affected by the scale of the diagram. Unit stress was taken to be that which produced the retardation corresponding to the tint of passage. A preliminary curve was drawn giving P − Q to x, as obtained from the

* Contribution to the report of the Committee of Section G of the British Association on Complex Stress Distributions, Liverpool, September 18, 1923.

intersections of the isochromatics with O X. From this curve the values of P − Q corresponding to $x/r = 0{\cdot}1, 0{\cdot}2, 0{\cdot}3$, etc., were read off, and Δy was the vertical intercept for these values of x between the isoclinics $\phi = +5°$ and $\phi = -5°$, so that $\Delta\phi$ = arc 10°. The results are shown in Table I.

TABLE I.—*Calculation of P along O X.*

x/r	P − Q	Δy (in.)	$\frac{(P-Q) \text{ arc } 10°}{\Delta y}$	P		Q	
				Graphl.	Theory.	Graphl.	Theory.
0·0	4·08	∞	0	0·84	1·06	−3·24	−3·18
0·1	3·94	3·05	0·226	0·81	1·02	−3·13	−3·10
0·2	3·53	2·03	0·304	0·72	0·90	−2·81	−2·86
0·3	3·04	1·45	0·366	0·61	0·74	−2·43	−2·51
0·4	2·53	1·08	0·409	0·48	0·56	−2·05	−2·09
0·5	2·03	0·88	0·403	0·35	0·38	−1·68	−1·66
0·6	1·50	0·74	0·354	0·23	0·24	−1·27	−1·23
0·7	1·00	0·65	0·269	0·13	0·12	−0·87	−0·85
0·8	0·60	0·59	0·178	0·06	0·05	−0·54	−0·52
0·9	0·28	0·59	0·083	0·01	0·01	−0·27	−0·23
1·0	0	0·60	0	0	0	0	0

The integration for P (graphical) was carried out by simple addition of mid ordinates. The columns marked P (Theory) and Q (Theory) were computed as follows. The values of Q obtained graphically were taken from the seventh column and $\int_{-r}^{+r} Q\,dx$ computed. This was found to be 10·84 and this value was taken as the total applied force F and the theoretical stresses for a disc under forces F applied along a diameter were computed. The Q values are seen to agree quite well. The P values shown by the graphical analysis are somewhat lower (but not really by large absolute amounts) than the theoretical values; but the spread of the applied pressure already mentioned would act in this sense.

The next step was to compute P along the lines of stress marked A, B, C, D in Fig. 2 (E was omitted as the observed lines were too crowded for the drawing to have been sufficiently accurate). Formula (7) was now used, bearing in mind that at the boundary P_0 is zero; and the observed values are tabulated for the intersections of the stress line with the successive isoclinics.

TABLE II.—*Calculation of P along lines, A, B, C, D of principal stress.*

	ϕ (Obs.)	ψ (Obs.)	(P−Q) (Obs.)	(Q−P) × cot ψ	P (Graphl.)	Q (Graphl.)
	deg.	deg.				
	17·0	—	0·0	0·0	0·0	0·0
	15·0	161·5	0·40	1·20	0·02	−0·38
A	10·0	157·5	1·50	3·62	0·18	−1·32
	5·0	151·5	2·72	5·00	0·56	−2·16
	0·0	90·0	4·20	0·0	0·93	−3·27
	32·5	—	0·0	0·0	0·0	0·0
	30·0	144·5	0·28	0·39	0·01	−0·27
	25·0	144·0	0·89	1·23	0·06	−0·82
B	20·0	143·0	1·60	2·13	0·21	−1·39
	15·0	137·5	2·50	2·72	0·42	−2·08
	10·0	131·0	3·27	2·84	0·67	−2·60
	5·0	124·0	3·91	2·62	0·92	−2·99
	0·0	90·0	4·35	0·0	1·06	−3·29
	48·0	—	0·0	0·0	0·0	0·0
	45·0	134·0	0·43	0·42	0·01	−0·42
	40·0	131·0	0·83	0·72	0·06	−0·77
	35·0	129·0	1·44	1·17	0·14	−1·30
C	30·0	129·5	2·00	1·64	0·27	−1·74
	25·0	124·0	2·90	1·94	0·42	−2·48
	20·0	121·0	3·60	2·16	0·60	−3·00
	15·0	122·0	4·15	2·57	0·80	−3·35
	10·0	115·5	4·55	2·18	1·02	−3·53
	5·0	108·0	4·82	1·54	1·18	−3·64
	0·0	90·0	4·85	0·0	1·25	−3·60
	63·0	—	0·0	0·0	0·0	0·0
	60·0	128·0	0·75	0·58	0·01	−0·74
	55·0	118·0	1·90	1·01	0·08	−1·82
	50·0	114·0	2·85	1·27	0·17	−2·68
	45·0	113·0	3·40	1·44	0·29	−3·11
	40·0	113·0	3·90	1·65	0·42	−3·48
D	35·0	113·0	4·25	1·80	0·57	−3·68
	30·0	115·0	4·70	2·19	0·74	−3·96
	25·0	114·0	5·15	2·20	0·93	−4·22
	20·0	108·0	5·55	1·90	1·12	−4·43
	15·0	105·0	5·90	1·58	1·27	−4·63
	10·0	101·5	6·15	1·25	1·39	−4·76
	5·0	97·0	6·30	0·77	1·48	−4·82
	0·0	90·0	6·40	0·0	1·50	−4·90

In computing the above table the values of (Q−P) cot ψ were plotted to ϕ on squared paper and the areas read off by counting squares. It will be noticed that we have now a system of values of P and Q which practically cover the whole of the disc, excluding the immediate neighbourhood of the points of application of the load. Our problem is therefore practically solved.

Comparison with the theory along the diameter $x = o$ shows divergences, *e.g.*, the progressive rise as we move away from O in the value of P, which in the theoretical example should be constant; but these discrepancies might be plausibly accounted for by the fact that the theoretical distribution of load is not accurately realised. The real test of the validity of the method lies in the agreement between the values of P and Q obtained at the same point by integration along lines of principal stress belonging to different (*i.e.*, orthogonal) systems.

In order to apply such a check, the value of Q at $x = 1{\cdot}5$ in., $y = 0$, where the line of principal stress marked c in Fig. 2 begins, was interpolated from Table II and found to be −1·845 in our units. Q and P were then computed for various values of ϕ along the line c, from the data given in Table III, each successive entry in the fifth column being obtained by adding to the preceding the arithmetic mean of the two corresponding entries in the fourth column.

TABLE III.—*Calculation of P and Q along the line "C" of Principal Stress.*

ϕ	ψ	P−Q	(P−Q) × (cot ψ) × arc 5°	Q	P
deg.	deg.				
0·0	90·0	2·25	0·0	−1·85	0·40
5·0	67·0	2·33	0·086	−1·89	0·44
10·0	57·0	2·38	0·135	−2·00	0·38
15·0	47·0	2·53	0·206	−2·17	0·36
20·0	41·0	2·70	0·271	−2·41	0·29
25·0	31·5	3·30	0·471	−2·78	0·52
30·0	29·0	4·00	0·630	−3·33	0·67
35·0	24·5	4·70	0·900	−4·09	0·61
40·0	18·0	5·50	1·477	−5·28	0·22

Finally, if we estimate the values of ϕ at the four intersections Ac, Bc, Cc, Dc and compare the values of P and Q obtained from Tables II and III by interpolation, we obtain Table IV below.

TABLE IV.—*Cross-check of Stresses.*

ϕ	Point.	P (II)	P (III).	Q (II).	Q (III).
deg.					
6·5	Ac	0·45	0·43	−1·91	−1·92
15·0	Bc	0·42	0·36	−2·08	−2·17
23·5	Cc	0·47	0·45	−2·64	−2·66
33·0	Dc	0·64	0·63	−3·79	−3·79

The slight difference shown in the values of P − Q in the above is due to the fact that the values of P and of Q were interpolated for separately. Looking at these values, however, the agreement is singularly good, and may be regarded as a remarkable confirmation of the accuracy of the method. It appears, therefore, that it is practically feasible to obtain the complete stress system in a transparent model from purely optical observations and without reference to the elastic properties of the material.

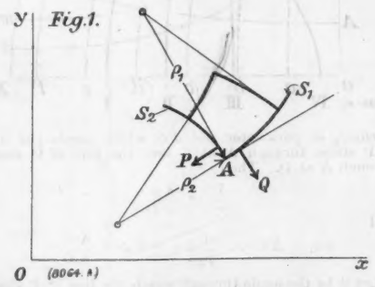
The best thanks of the author are due to Mr. H. T. Jessop, M.Sc., of University College, London, who actually annealed the specimen of bakelite used in these observations and who obtained the tracings of the isoclinic and isochromatic lines.

THE DETERMINATION OF STRESSES AT A POINT IN A PLATE.

*A Comparison of Experimental Methods for Obtaining the Stress at a Point in a Plate by Optical and Mechanical Methods.**

By E. G. Coker, F.R.S., Professor of Civil and Mechanical Engineering, University of London, University College.

During the last twenty years a very large amount of attention has been given to methods of measuring the stress at a point in a plate loaded in its own plane, and considerable progress has attended these efforts. In



opaque materials the surface of the plate may be covered by ruled networks and the strains examined under load. Sections of dams have been examined in this way by Pearson† and his pupils, using rectangular networks and measuring the angular changes at the nodes, more particularly for determining the distribution of shear stress in a dam due to its weight and the applied water pressure. Sections of dams and other plate forms have also been examined by Wilson and Gore‡ and Wilson alone§, using systems of circles which are deformed into elliptical forms under load and afford measures of the principal stresses and their directions. Much attention has also been devoted to the utilisation of the effect, discovered by Brewster, that transparent models under load exhibit doubly refractive effects, which in a plate afford a measure of the difference of the principal stresses P and Q due to absolute retardations of the two wave systems caused by the stressed material. The retardation in one wave system is proportional to P, in the other is proportional to Q, and by causing an interference effect between them, a differential effect can be measured proportional to (P − Q).

From time to time after Brewster's discovery attempts were made to utilise the interference effect to measure stress distribution, but with little success. A notable contribution was made by Clerk Maxwell* who showed that a map of the isochromatics and isoclinics, together with measurements of (P − Q), is theoretically sufficient to determine the stress distribution completely. In his method if the isochromatic bands are defined by

$$\phi_1(x, y) = C(P - Q)T \quad . \quad . \quad (1)$$

where C is an optical constant, and T is the thickness of the plate; and the isoclinics by

$$\phi_2(x, y) = \tan\theta = \frac{dy}{dx} \quad . \quad . \quad (2)$$

then at any point A, Fig. 1, of a node in the lines of principal stress we have

$$(Q - P) = \rho_2 \frac{\partial P}{\partial S_1} = \rho_1 \frac{\partial Q}{\partial S_2} \quad . \quad (3)$$

obtained by considering any particle of the plate as a portion of a cylinder, the axis of which passes through the centre of curvature and bounded by orthogonal lines of principal stress. It is worthy of note that these latter relations of Clerk Maxwell anticipate the well-known equations of Lamé† for a plate, although it is possible they may have occurred in an earlier paper. If, now, ρ_2 and S_1 are expressed in the form

$$\phi_3(x, y) = \rho_2 \quad . \quad . \quad . \quad (4)$$

and

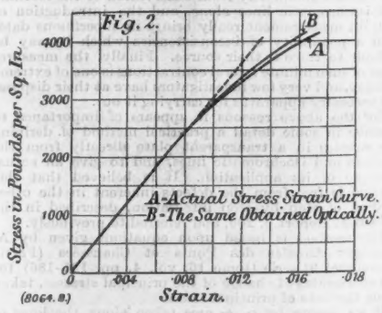
$$\phi_4(x, y) = S_1 \quad . \quad . \quad . \quad (5)$$

there are sufficient relations to determine the stress distribution along a line of principal stress P, provided an initial value of the stress is known, which Clerk Maxwell suggests shall be at a contour free from applied load.

The difficulty of expressing the required forms of the various ϕ functions, and especially the equations involving the curvature relations, is, however, so great that although the solution is complete, it is unworkable practically.

If, however, it were possible to express these functions correctly in any given case, a further difficulty would be met with that the stress values obtained along a given line of stress depend on the correct determination of the preceding values, so that errors are cumulative and tend in general to increase with the distance from the starting point. This is in fact one of the sources of error of all the purely optical methods proposed so far, but a suggestion is made below which, if it can be applied, would avoid this particular difficulty.

A later method, used extensively by the author, avoids the mathematical difficulties inherent in the above method, and is due to a suggestion by Mesnager that the lateral change of thickness in a plate can be used to obtain a measure of the sum of the principal stresses (P + Q) at a point. We then have P, Q, θ_P and θ_Q, all



measurable directly at any given point without any of the difficulties which arise in approaching a given point from a distance. In a perfectly elastic body there are no theoretical errors for plates of moderate thickness, so that the mean average stress throughout the thickness of the plate for both (P ± Q) measurements can be taken as the true stress. There is, however, a possible source of error when the transparent materials used are not perfectly elastic, but it has been shown‡ in the case of good samples of nitrocellulose, for example, that up to a range of about 3,500 lb. per square inch (Fig. 2) the optical measurements are accurate to 2 or 3 per cent. The mechanical and optical measurements, of a stress strain curve, in fact, lie approximately on a straight line up to about 2,500 lb. per square inch

* Communicated to Section G, British Association Meeting, Liverpool, September, 1923.

† "On Some Disregarded Points in the Stability of Masonry Dams," by L. W. Atcherley and Karl Pearson, also "An Experimental Study of the Stresses in Masonry Dams," by Karl Pearson and A. F. C. Pollard, Drapers' Company Research Memoirs, 1904 and 1907.

‡ "Stresses in Dams," by J. S. Wilson and W. Gore, Min. Proc. Inst. C.E., 1908. See also Engineering, vol. lxxx, page 692.

§ Institution of Naval Architects, 1911. See also British Association Report on "Complex Stress," Liverpool, 1923: page 446 *ante*.

* "On the Equilibrium of Elastic Solids," by Mr. James Clerk Maxwell. Trans.Roy.Soc., Edin., 1850, and Collected Papers.

† Page 274 of "Leçons sur es Co-ordonnées Curvilignes," by G. Lamé, 1859.

‡ "The Stress-Strain Properties of Nitro-Cellulose and the Law of its Optical Behaviour," by Professor E. G. Coker, F.R.S., and K. C. Chakko, M.Sc. *Phil. Trans.*, R.S., 1920.

for this material. The lateral measurements are also of about the same degree of accuracy when these are referred to a standard member cut from the same plate. The possible sources of error from this cause in the numerous other transparent bodies available for experiment have not so far been examined with any accuracy.

A second purely optical method* makes use of the well-known equations

$$\frac{\partial \widehat{xx}}{\partial x} + \frac{\partial \widehat{xy}}{\partial y} = \frac{\partial \widehat{xy}}{\partial x} + \frac{\partial \widehat{yy}}{\partial y} = 0 \quad . \quad . \quad (6)$$

for the equilibrium of a small rectangular element of a plate, from which we get at once by integration:

$$\left.\begin{aligned} \widehat{xx} - \widehat{xx}_0 &= -\int \frac{\partial \widehat{xy}}{\partial y} . dx \\ \widehat{yy} - \widehat{yy}_0 &= -\int \frac{\partial \widehat{xy}}{\partial x} . dy \end{aligned}\right\} \quad . \quad . \quad (7)$$

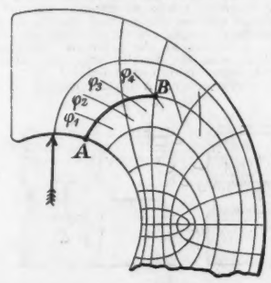
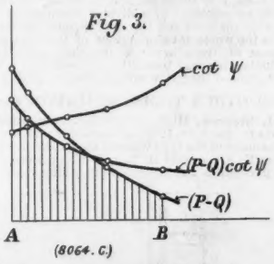


Fig. 3.



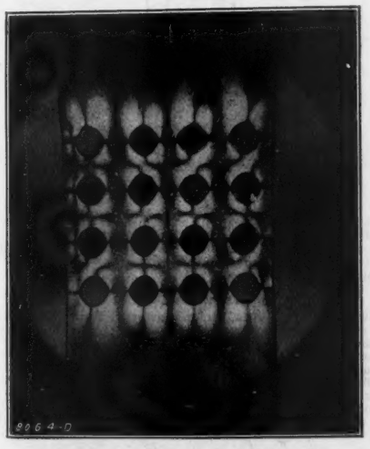


FIG. 4.

We also have by resolution of the stresses

$$2 . \widehat{xy} = (P - Q) \sin 2\theta$$

so that along any line parallel to the co-ordinates the stresses $\widehat{xx}$ and $\widehat{yy}$ can be determined by an approach method in terms of the difference (P − Q) of the principal stress along this line and their inclinations, provided the initial values $\widehat{xx}_0$ and $\widehat{yy}_0$ are known and can be measured. The principal difficulties encountered here are the accurate evaluation of the partial differential coefficients $\frac{\partial \widehat{xy}}{\partial x}$ and $\frac{\partial \widehat{xy}}{\partial y}$, and the determination of the points of intersection of the isoclinic bands with the chosen direction of integration and the inclinations θ, and as the errors are cumulative and may be large, the method has not so far been used in practice.

Professor Filon has recently suggested another purely optical method* which, in some respects, follows the lines of Clerk Maxwell's method, but avoids the difficulty which is caused by the introduction of the expressions for the curvatures of the lines of principal stress. In his method by integrating equations (3) we have

$$P = P_0 + \int (Q - P) \frac{d S_1}{\rho_2} = P_0 + \int_{\phi_0}^{\phi} (Q - P) \cot \psi . d\phi \quad (9)$$

$$Q = Q_0 + \int (Q - P) \frac{d S_2}{\rho_1} = Q_0 + \int_{\phi_0}^{\phi} (Q - P) \cot \psi_1 . d\phi \quad (10)$$

where ψ and ψ_1 are the inclinations of the lines of principal stress to the isoclinics, and the summation

Fig. 5.

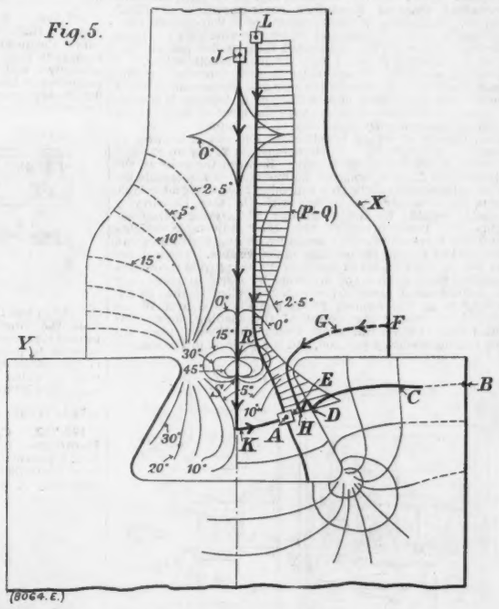
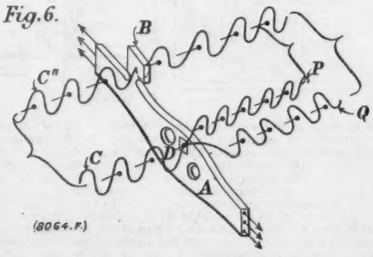


Fig. 6.



required is along a line of principal stress starting from a convenient place where there is no transverse stress. As will be seen, the summation involves the product of three variables, (*a*) the stress difference, (*b*) the inclination of the curved isoclinics to the line of stress, and (*c*) the isoclinic parameter. Its accuracy depends, therefore, on the ability to measure these three quantities as we proceed along a given line of stress, and to sum the integral. Thus, if we start from a point A of the hook, Fig. 3, on a given line of principal stress where, say, $P = P_0$, we may plot the values of P − Q and cot ψ observed and obtain by multiplication a curve (P − Q) cot ψ, the area of which above the abscissæ A B, Fig. 3, added to the value P_0, gives a measure of the value of the stress at B.

The principal difficulty here is in estimating the angles between two sets of intersecting curved lines and especially the exact point of intersection, since in practice the isoclinics are bands of some width of the type shown in the photograph, Fig. 4 for a perforated tension member and the more acutely they cut the lines of principal stress the more difficult it becomes to locate their points of intersection. It is, moreover, to be remembered that the lines of principal stress are derived from the isoclinic bands, and are not constructed from independent data, so that some judgment is needed in the construction of a map of each.

The more favourable cases of intersection are those in which the two sets of curves intersect at large angles, which arrangement gives, in general, more numerous points of observation. If, however, the intersecting angles become very small, a slight error in ψ is serious, since cot ψ occurs in the summation and the points of observation are also then far apart. In such cases, and especially along a line of symmetry, it may be more convenient to measure the distance Δy between two isoclinic bands, and the equation (9) becomes of the type

$$P = P_0 + \Delta\phi \int \frac{P - Q}{\Delta y} . d S_1 \quad . \quad . \quad (11)$$

with a similar expression for Q.

Some of the cases of practice afford interesting problems, one of which may be considered by reference to one case of a member X, Fig. 5, attached to a member Y by a dovetailed joint, in which the two parts of the joint are in contact throughout and are forced together so that there is stress initially across the boundaries. A great variety of such joints are used in practice, especially in the construction of armatures of electrical machines and the like, where a number of such joints are arranged radially at regular angular intervals. Let us suppose that the stress at a point A is required well within the dovetail. A number of paths are open to us, but some must be excluded on account of special difficulties. Passage across the contact boundary in any direction is one of these, for, as will be seen, if the stress line B C D E A is taken, a stress discontinuity is encountered at E D owing to the possibility of shear stress developing between the contact surfaces, while the part B C of the line is indeterminate owing to the isoclinic bands merging into a dark field with no obvious direction in this region. The shortest stress line is F G H A, of which the part F G is indeterminate for the same reasons and involves a right-angled turn at H to reach A. Passage along the central axis is also possible, and in this case it would probably be preferable to start from a point J where the stress is a uniform tension and to make use of the general formulæ of (9) and (10), as no one pair of bands can be employed to measure A *y*. This line has the peculiarity that at two points R and S upon it the isoclinics are many valued owing to the P and Q stresses being practically equal at these places. At K a right-angled turn is made to reach A. Possibly, however, the simplest and most accurate plan is to start at point L where there is simple tension on a line of stress passing through A and to determine the integrals of the general equations (9) and (10) using the measured values of (P − Q) which are roughly sketched, in this figure, as ordinates to the line of stress, as are also the isoclinics involved. A purely optical treatment by any other method described above would probably prove very inaccurate. The case of an armature with a number of such joints would probably not present any further difficulties, except possibly those due to a somewhat more intricate network of isoclinics, which latter are now being examined.

It will be seen from this account of the various methods employed to measure stress distribution in transparent models that, in order to determine the stress distribution at any given point, two stress magnitudes are required, and also two angular directions at right angles; so that in the general case three independent quantities must be fixed and the minimum number of measurements to obtain them is not less than three in general; but in special cases at free boundaries these reduce to one measurement, as one stress is then absent and the contour gives the two angles. In this latter case all methods of optical stress measurement coincide, but a combined optical and mechanical measurement gives two independent values, since Q = 0 and P − Q = P + Q. This is useful in practice, and a complete investigation of the stress distribution in a model can be checked on its metal counterpart by a comparison of the values of (P + Q) on both, and this has occasionally been used to demonstrate beyond all doubt that unsuspected stress distributions exist in parts of engineering structures similar to those found in transparent models. Thus it has been shown* along the sides of a bar with a hole in it, that the maximum stresses at the straight contours are separated by a considerable interval on each side of the minimum cross-section, a fact first observed and measured in a transparent model and confirmed in some perforated steel bars.

Such confirmations, although in most cases strictly unnecessary, are not without value, as they form a connecting link between laboratory experiments of a physical character and the full-size structures of engineering practice. It is probable that much of the experimental work which has been done on metal structures by measuring strains directly by the methods described in the first part of this paper could be extended profitably if lateral measurements were substituted. At points removed from the contour all measurements of stress distribution of a purely optical character involve methods of approach along some line, and the number of observations and the method of their combination depend on the character of the method employed and the special circumstances of the stress distribution. It does not appear impossible, however, for a purely optical method to be devised in which an approach to an end value from a given starting point can be dispensed with. In fact, only one part of the optical combination appears to be wanting. Take, for example, any transparent member A, Fig. 6, under stress. In order to find the stress at a point D in it, a plane or circularly polarised beam is transmitted through the plate at this point, which divides into two waves P and Q with retardations proportional to the stresses P and Q respectively, and let us say also proportional to some

* "Experimental Determination of the Distribution of Stress and Strain in Solids," by Professors Filon and Coker, British Association Report, 1914, pages 201 to 210.

* Report of the British Association Committee "On Certain of the More Complex Distributions of Stress in Engineering Materials," Liverpool, 1923, page 511 *ante*.

* "Photo-Elastic and Strain Measurements of the Effects of Circular Holes on the Distribution of Stress in Tension Members," by Professor E. G. Coker, K. C. Chakko and Y. Satake, Proc. Inst. of Engineers and Shipbuilders in Scotland, 1919. See also ENGINEERING, vol. cix, page 298.

unknown value depending on the thickness of the unstressed plate. To eliminate this latter effect a part of the main beam C is transmitted as a subsidiary beam through an unstressed part of the same plate, formed conveniently as a projection B thereon. A comparison of the retardation between C″ and P and C″ and Q, respectively, gives the absolute retardation due to the principal stresses and therefore a measure of the stresses themselves. This reduces a purely optical system to the ideal number of three measurements to fix the stress distribution at a point. Possibly the comparison of the retardations could be made by a Babinet compensator, or a combination of this with a Michelson interferometer for adjustment of the lengths of paths traversed by the main and subsidiary waves C and C″. We have still wanting a means of separating the P and Q waves, as they emerge in order to give an ideal system of optical stress measurement, and if this can be supplied the arrangement appears to be a feasible one. Whatever variation of this may be employed eventually, the principles of this method must be used, since the phenomena of artificial double refraction cannot be modified.

CATALOGUES.

Electrical Supplies.—A catalogue giving prices and particulars of lamps, switches, bells, fuses, reflectors and other electrical fittings and accessories, has come to hand from Messrs. Donovan and Co., 47, Cornwall-street, Birmingham.

Graphite for Boilers.—A small explanatory pamphlet relating to the use of graphite for removing and preventing incrustation in boilers has been issued by the Joseph Dixon Crucible Company, 22, Duke-street, Stamford-street, London, S.E.

Electric Controls.—Copies of new issues of their excellently-arranged catalogues dealing with series-parallel starting switches of the air break type for two-phase, squirrel-cage induction motors and with direct current control panels, are to hand from The British Thomson-Houston Company, Limited, Rugby.

Automatic Telephone.—A pamphlet containing a brief description of the construction and method of using their automatic telephone system has been issued by the Relay Automatic Telephone Company, Limited, Marconi House, Strand, London. The system was illustrated and very fully described in vol. cxiv of Engineering on pages 406, 422 and 448.

Coal-Cutting Machines.—A catalogue and a number of leaflets relating to coal-cutting machines of the bar, chain and disc types, have come to hand from Messrs. Mavor and Coulson, Limited, 47, Broad-street, Mile End, Glasgow. Some machines of the bar type made by this firm were illustrated and described on pages 615 and 648 of our last volume.

Electric Condensers.—The Telegraph Condenser Company, Limited, Vauxhall-street, London, S.E. 11, send a revised issue of a catalogue dealing with their static condensers for the improvement of power factor on alternating-current systems and giving tables and data for calculating the size of condenser suitable for any particular purpose.

Power Plant Accessories.—A list of fittings including a feed-water regulator, pump governor, safety device for oil and gas-fired boilers, electric light for gauge glasses, high and low-water alarm, and a variety of packings and jointing materials is to hand from Messrs. Ronald Trist and Co., Limited, 12, Clipstone-street, Great Portland-street, London, W. 1.

Electric Heating and Cooking Apparatus.—A catalogue illustrating a variety of electric heaters, is to hand from the General Electric Company, Limited, Magnet House, Kingsway, London, W.C. 2., who have also issued another catalogue giving particulars of a very large variety of electrically heating cooking utensils for domestic and industrial use. Prices are stated in all cases.

Foundry Supplies and Testing Work.—Messrs. Beecroft and Partners, Limited, have sent us copies of their circulars of preparations for fluxing iron, and treating sand used for making cores. This firm, whose offices are at St. Peter's Close, Sheffield, and at Norfolk House, Cannon-street, Birmingham, also undertakes the analysis and physical testing of metals, alloys, fuels, refracting materials, &c.

Dissolved Acetylene.—The properties and applications of dissolved acetylene and the construction of the cylinders, for its storage and blowpipes, lights, &c., for its use, are fully described with illustrations, dimension tables and prices in a catalogue received from Messrs. Allen-Liversidge, Limited, 106, Victoria-street, London, S.W. 1. The contents show that the firm aims at supplying every requisite fitting and give a fair statement of cost, with much useful and practical information.

Steam Engines and Boilers.—A new issue of their catalogue of steam engines and boilers by Messrs. Tangyes, Limited, Birmingham, includes examples of single-cylinder, two simple cylinder, compound condensing and non-condensing engines of both vertical and horizontal types and suitable for various working pressures. Each type is made to standards in various powers, ranging from 2 b.h.p. to about 250 b.h.p. These engines cover the requirements of general work in factories, &c. and the inference for power users is that they should invite the advice of the engine maker as to the type most suitable and economical for working under the conditions to be complied with in any particular case. The boilers illustrated are of the vertical cross-tube locomotive and "Colonial" types and full particulars are given of various sizes of each type.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

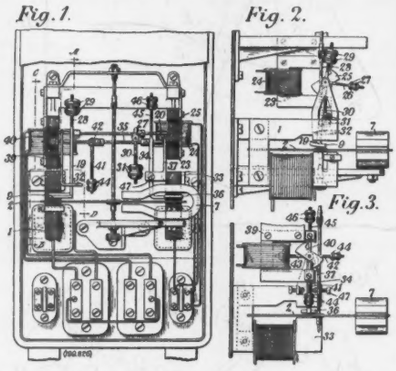
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

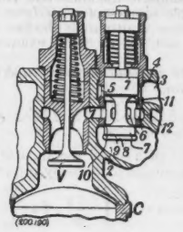
199,826. G. F. Shotter, London, and E. W. Hill, London. Alternating Current Electrical Instrument. (5 *Figs.*) March 31, 1922.—The invention relates to a volt-ampere hour meter and a maximum demand meter for alternating current of the kind comprising an unsaturated main shaded pole electro-magnet 1 connected in series with the load, a rotatable disc 2 of metal in proximity to the poles thereof, a continuous flux magnet 7 with its poles close to the disc and mechanism to count or record the revolutions of the disc, or a demand indicator. The invention comprises means to vary the speed of the rotatable disc in accordance with variations of the supply voltage. A shading piece 9 of copper is carried at one end of an arm 19 mounted on a spindle 20. An electro-magnet 23 has an exciting coil 24 connected across the supply. Between the poles of the electro-magnet 23 is an armature 25 mounted on the spindle 20. Also mounted on the spindle 20 is a member 26 carrying adjustable weights 27, a member 28 in line with the arm 19 carrying adjustable weights 29 and a member 30 carrying adjustable weights 31. These members with their adjustable weights control the movements of the armature 25 and their effect can be adjusted by varying the positions of the weights. The member 26 is set at right angles to the arm 19 to provide a constant controlling force so that the armature 25 starts to move only at a predetermined value of the voltage applied to the coil 24. The weights on the member 28 in line with the arm 19 are employed to balance the weight of the shading piece. The member 30 is in a vertical position when the shading piece 9 is in the minimum voltage position, and the position of the shading



piece in the gap of the electromagnet 1 may be varied for any given voltage by adjusting the weights 31. In the minimum voltage position the armature 25 through the spindle 20 and the controlling weights causes the shading piece to assume a position at the end of the air gap, as shown in Fig. 2. As the voltage rises the armature 25 turns and so moves the shading piece into the gap, thus causing an increase in the speed of the disc 2. The restoring force due to the weights 31 increases from zero as the shading piece 9 is moved into the air gap of the electromagnet 1. The weights are adjusted so that the shading piece only moves between certain predetermined values of the voltage. Projections 32 on a bracket member control the extent of movement of the shading piece 9. 33 is a second shaded pole electromagnet whose shading piece 36 is mounted on a member 34 to move between the poles. The member 34 is mounted on a spindle 35. An electromagnet 39 is connected in series or parallel with the main shaded pole electromagnet 1 and between its poles is arranged an armature 40 rigidly mounted on the spindle 35. Also mounted on the spindle 35 are members 41, 42 and 43, each carrying adjustable weights 44. A further member 45 in line with the member 34 carries weights 46 to balance the weight of the shading piece. The shading piece 36 is so arranged that it gives a minimum added torque to the disc 2 when it is in the mid-position and a predetermined maximum value when it is moved over towards the edge of the pole. Thus, by this means the added torque due to the second shaded pole electromagnet 33 is varied with the load current. Extensions, such as screws 47, on the member 37 control the extent of the movement of the shading piece 36. (*Sealed.*)

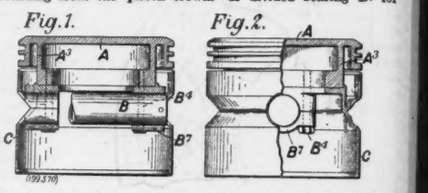
GAS ENGINES, PRODUCERS, HOLDERS, &c.

200,190. C. Day, Stockport. Internal-Combustion Engines. (5 *Figs.*) April 6, 1922.—The invention relates to internal combustion engines working on the four-stroke cycle using a single valve combined with a deflector of the cylindrical piston valve type disposed apart from the single valve and working in a separate cylindrical chamber. The invention consists in combining with the piston valve portions of the deflector, two mushroom valve faces. C is the working cylinder of the engine, V is the valve which controls both the inlet of gases to the cylinder and the exhaust from the cylinder. 1 is the passage between the valve chamber and the deflector chamber, 2 is the exhaust passage. 3 is the passage leading the inlet gases to the deflector. 4 is a liner provided with ports 5 communicating with the passage 3 and with ports 6 communicating with the passage 1. 7 is the deflector which has two cylindrical portions sliding in the liner 4. The deflector performs the function of bringing the passage 1 into communication with the passage 2 or with the passage 3. On the lower cylindrical part of the deflector 7 is a cylindrical enlargement 8, and a mushroom valve face 9 is formed at the point of junction of the enlargement 8 and the cylindrical part 7. On the lower end of the liner 4 a mushroom valve seat 10 adapted to receive the face 9 is formed. The upper part of the deflector 7 is provided at its lower end with a mush-



room valve face 11 adapted when the deflector is in its lowest position to seat itself on a mushroom valve seat 12 for which provision is made by reducing in diameter the lower part of the liner in which the deflector slides. (*Sealed.*)

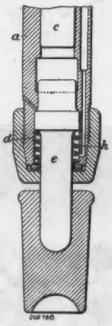
199,570. E. Talbot, Lowestoft. Pistons. (5 *Figs.*) May 20, 1922.—The invention relates to pistons of the kind in which the head or part carrying the packing rings is formed separately from the skirt or bearing portion and is subsequently connected with it. According to the invention, the piston comprises a head A carrying the packing rings and a skirt C detachably connected therewith through a reduced portion A^3 extending from the piston crown. A divided bearing B^7 for



the piston pin B is carried by the skirt and is wholly distinct from the ring-carrying portion. This divided bearing may be formed separately from the head and the skirt thereby making it possible to machine the whole interior surface of the skirt and of the piston because of the absence of irregular projections upon its walls. The bearing may be united to the skirt by the same bolts B^4 which connect the latter with the head. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

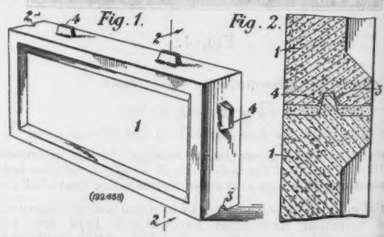
199,782. C. H. Stevens, High Wycombe. Pneumatic Hammers. (2 *Figs.*) March 23, 1922.—According to the invention, a pneumatic hammer of the type wherein the handle grip and hand controlled throttle are located at the rear or upper end of a tool body *a*, which contains the reciprocating piston *c* and is



furnished at its forward end with a tool member *e* working against an air cushion in the known way, is characterised in that the air cushion chamber *d* is in constant open communication with the throttle valve in the handle grip by a passage *h* passing through the side wall of the tool body. (*Sealed.*)

MISCELLANEOUS.

199,468. J. E. Wallis, Rickmansworth. Building Blocks. (3 *Figs.*) March 23, 1922.—The invention relates to building blocks. The block 1 is formed along one vertical and one horizontal jointing face with central grooves 2, 3, respectively, which extend parallel to the outer faces of the block. These grooves are flat-bottomed and are wedge-shaped in cross-section. The block is also formed along the other horizontal and vertical jointing face with projections in the form of short registering nibs 4. These nibs are disposed in line with one another and are



situated along a line extending parallel to the outer edges of the block and disposed midway between them. The nibs 4 are flat at the top and are preferably wedge-shaped in cross-section. The breadth of the nibs at the top is equal to the width of the grooves at the bottom, so that when the block is built in place upon and against other blocks similarly formed, the nibs register with and closely fit the bottom of the grooves of the adjacent blocks. The sides of the nibs, however, are preferably sloped to a less extent than the sides of the grooves as shown. (*Sealed.*)

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